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A PROXIMATE BIOLOGICAL SURVEY OF SAN DIEGO BAY, CALIFORNIA

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January 1975

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From December 1972 to June 1973 a literature review and field-sampling program were conducted to acquire environmental information concerning San Diego Bay, California. The primary goal was to obtain data in the vicinity of local naval installations that could be used as a baseline in evaluating environmental conditions at other naval installations in temperate waters. A secondary goal was to document existing conditions in the bay. This report presents the results of the survey, including data on the historical uses of the bay,

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changes in water quality, and past and present biological conditions. On the basis of these data the following conclusions may be drawn: (1) After a period of decline, water quality in San Diego Bay is improving. (2) Domestic and industrial discharges into the bay have been virtually eliminated, except for raw sewage originating aboard military and civilian vessels and limited amounts of cooling and thawing waters. (3) State and local water quality requirements are stringent and well enforced, and it is estimated that most waste discharges into the bay, including all those from military sources, will be eliminated by 1980. (4) A number of marine organisms, including commercially and recreationally important species, are abundant in the bay.

SUMMARY

From December 1972 to June 1973 a literature review and field-sampling program were conducted to acquire environmental information concerning San Diego Bay, California. The primary goal was to obtain data in the vicinity of local naval installations that could be used as a baseline in evaluating environmental conditions at other naval installations in temperate waters. A secondary goal was to document existing conditions in the bay. This report presents the results of the survey, including data on the historical uses of the bay, changes in water quality, and past and present biological conditions. On the basis of these data the following conclusions may be drawn: (1) After a period of decline, water quality in San Diego Bay is improving. (2) Domestic and industrial discharges into the bay have been virtually eliminated, except for raw sewage originating aboard military and civilian vessels and limited amounts of cooling and thawing waters. (3) State and local water quality requirements are stringent and well enforced, and it is estimated that most waste discharges into the bay, including all those from military sources, will be eliminated by 1980. (4) A number of marine organisms, including commercially and recreationally important species, are abundant in the bay.

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INTRODUCTION

In 1971 the Marine Environmental Management Office of the Naval Undersea Center began to compile field data concerning the biology and related physical-chemical parameters of marine regions of interest to the U. S. Navy. The first efforts took place at Pearl Harbor, Hawaii, and Inner Apra Harbor, Guam, and yielded valuable information on tropical and subtropical conditions (Evans, 1972, and Evans, unpublished). To obtain comparable information for temperate and subtemperate waters similar surveys were planned for Navy ports on the west coast of the United States.

San Diego, California, situated at a latitude of 32° 40' north, has a range of surface water temperatures of 54.5°F to 78.8°F (12.5°C to 26°C). The city is the home port of over one-fourth of the U. S. Navy's active fleet and hosts one of the largest concentrations of naval personnel in the world. For these reasons San Diego Bay was a natural choice for a survey of conditions in the transitional zone between warm and cold waters. This survey, conducted between December 1972 and June 1973, had the primary goal of acquiring data that could be used as a baseline for environmental assessments in regions with similar environmental conditions and a secondary goal of documenting existing conditions in the bay. A map of the bay showing its chief geographical features is given in figure 1.

The present report offers a summary of the data collected during the survey. Since with the time and manpower available a full biological survey was not possible, the results are considered proximate rather than complete.

METHODS

The first step was that of gathering information from previous studies and following the changes that had occurred as San Diego Bay was developed. This information was obtained from numerous sources, including local universities and the San Diego office of the California Regional Water Quality Control Board. Three documents were of major importance in gaining background information and were drawn on extensively in writing the report: "Natural Physical Factors of the San Diego Bay Tidelands" (San Diego Unified Port District, 1972); "The Matter of Discharges of Sewage and Oil to San Diego Bay from United States Navy Vessels" (California Regional Water Quality Control Board, San Diego Region, 1972a); and "Draft Environmental Statement, San Diego Harbor, San Diego, California" (U. S. Army Corps of Engineers, 1973). A full list of the sources and documents consulted is given in the bibliography and appendix A.

As material was compiled it became apparent that, although a great deal of information was available in many areas, the fishes of San Diego Bay had been only slightly documented. To add knowledge in this area a fish sampling program was undertaken during April and May of 1973. Bacteriological and micromolluscan samples were also taken and certain physicochemical parameters measured.

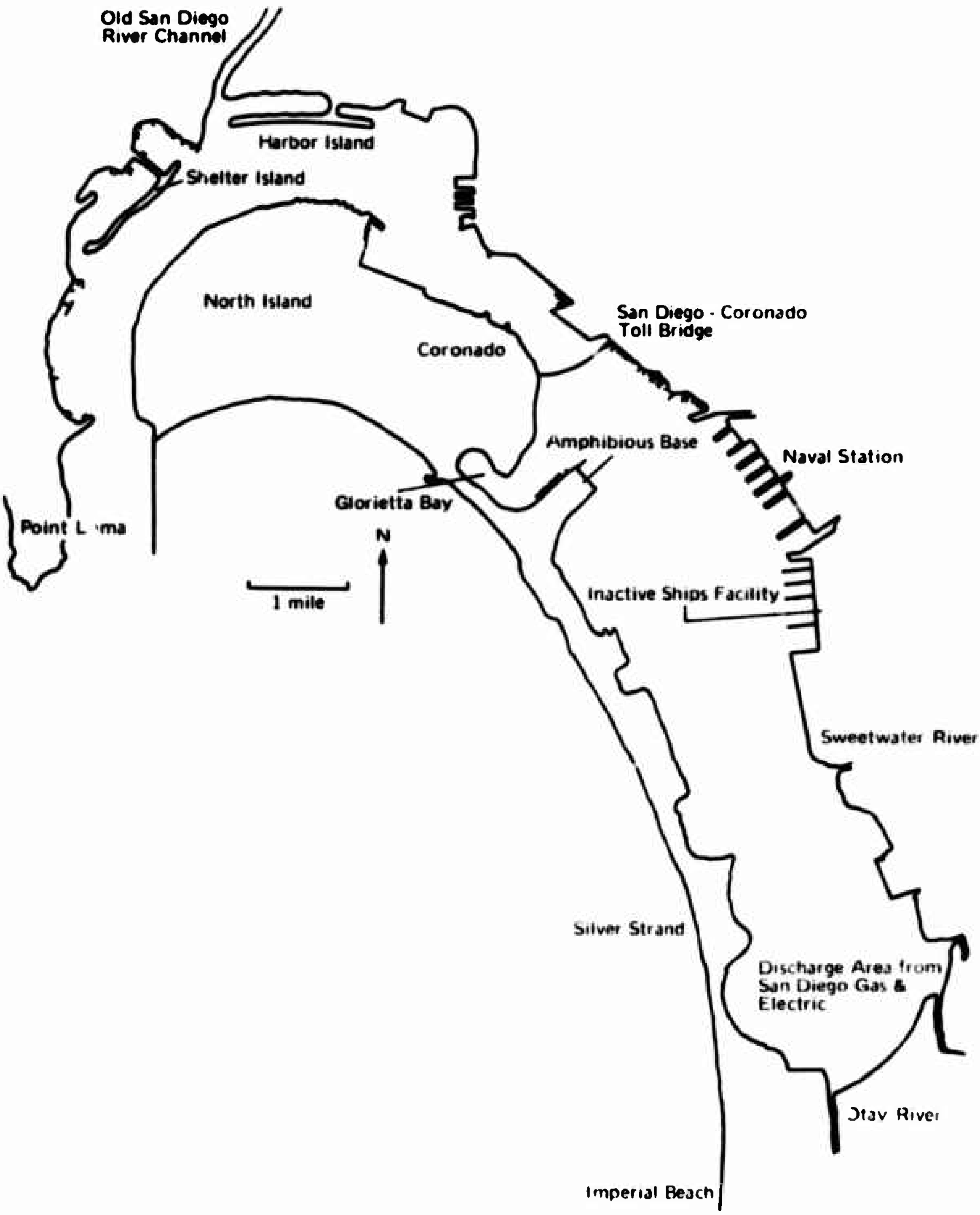


Figure 1. Map of San Diego Bay

Ten sampling stations were established at the locations indicated in figure 2 and table 1. These stations were so arranged that they included major naval installations and at the same time provided representative coverage of the bay. The extreme south end of the bay was omitted for lack of time, but the reader is referred to studies conducted by Richard Ford for the San Diego Gas and Electric Company (Ford, 1968 and 1970).

Each of the ten stations was sampled in the following manner:

1. Fish traps. Five trap sets of 72 hours each were made at each station. The traps consisted of a wire mesh over supporting rods, were 4 by 4 by 2 feet, and had a single-funnel entrance. Each was covered with algae, *Sargassum spp.*, so that a slight shadow was cast on the bottom, but no bait was used.

2. Gill nets. The ten stations fell natually into five "shallow" and five "deep" ones. A net of 7 by 100 feet was used at the shallow stations (no. 1, 2, 5, 7, 10) and a net of 20 by 100 feet at the deep stations (no. 3, 4, 6, 8, 9); both sizes were of 3-inch stretch mesh. All net sets were parallel to shore, covered the entire water column, and were of 24-hour duration. At least three net sets were conducted at each station except number 7, where operational schedules permitted only one. Because of heavy boat traffic the net sets for station 2 were made at a point corresponding to "2A" in figure 2.

3. Bacteriological sampling. Surface water samples from each of the ten stations were cultured, using the membrane filter technique (American Public Health Association, 1971), to determine their total content of coliform bacteria. Samples were taken and cultured three times during the two-month sampling period.

4. Micromolluscan sampling. Bottom samples of approximately 18 cubic inches (288 cubic centimeters) were collected at each station and analyzed for micromolluscan content (mollusks less than 10 millimeters in length). The samples were dried and sorted, and organisms that had been alive or possibly alive were identified and counted.

5. Physicochemical data. Temperature, conductivity, and dissolved oxygen were measured *in situ* at each of the ten stations with a field water-quality analyzer.* The oxygen measurements were periodically checked against laboratory measurements made with the Winkler method (Strickland and Parsons, 1968) and were found to be consistently low by a mean value of 0.46 parts per million.

GENERAL DESCRIPTION OF SAN DIEGO BAY

The purpose of this section is to provide an outline of the general environmental conditions of the San Diego Bay region, both those that occur naturally and those that have resulted from the activities of man. This information supplies a context for the biological information presented in the following section.

NATURAL CONDITIONS

Extensive tilting and slippage of the California crust occurred during the Pliocene, 10 to 15 million years ago, and it was during this period that the San Diego embayment was

* *Martek Instruments, Inc., Newport Beach, Calif., Model Mark 2*

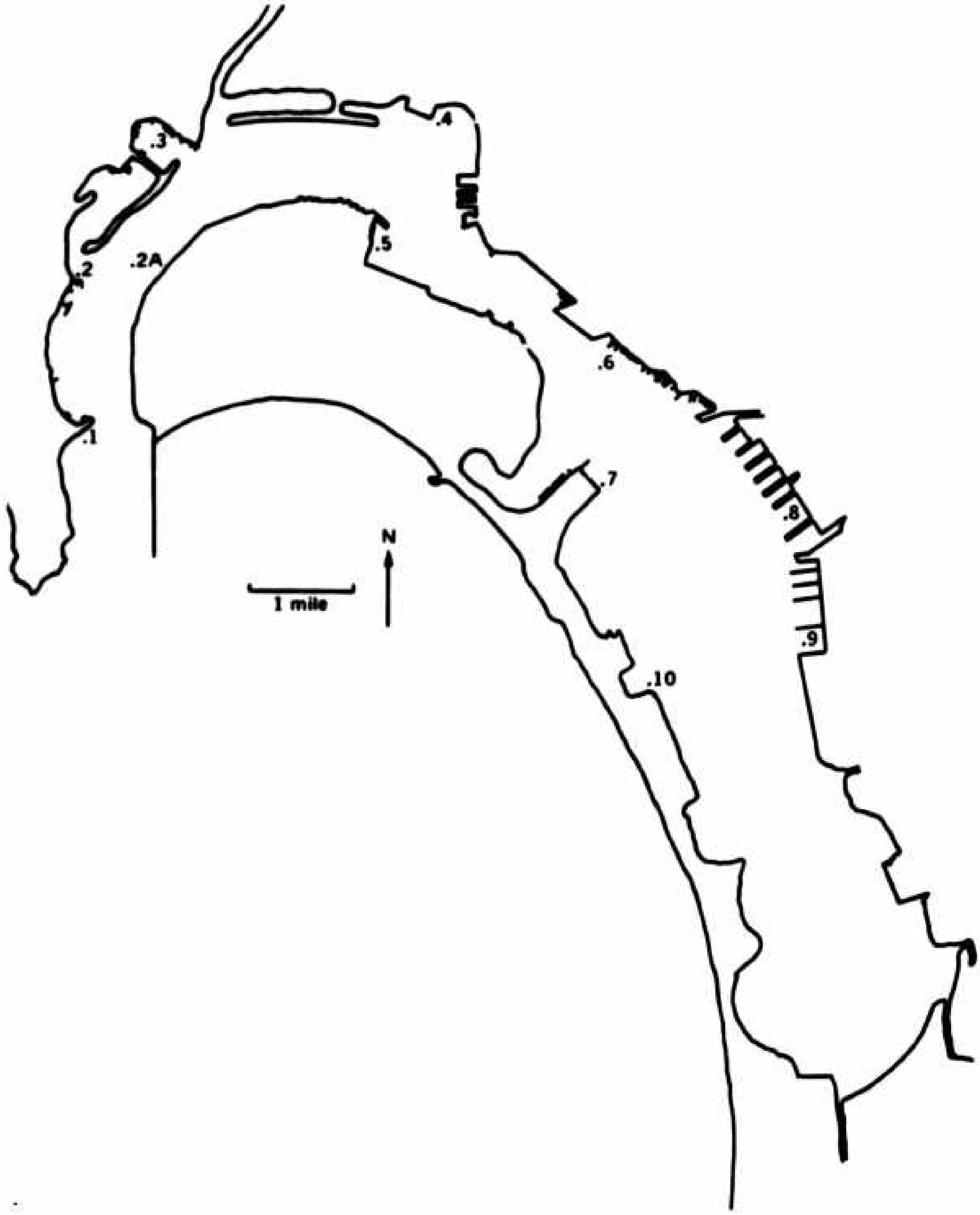


Figure 2. Location of sampling stations for Proximate Biological Survey.

formed (Moore and Kennedy, 1970). The bay is the shallow extension of the Sweetwater and Otay alluvial plains on the south and east, the littoral accumulation of Silver Strand on the west, and the San Diego River delta to the north. A narrow, natural channel has existed for some time in the mouth of the bay, possibly as a result of erosive outfalls from floods at a time when the ocean water level was much lower. Under a higher sea level, as apparent today, the submerged bay bottom has been in the gradual process of filling in (Lockheed Corp., 1967). Historically, the bay floor and bay margins were characterized by sand, silt, clay, and mud deposits. Sands were most common near the mouth and along the western margins, while finer mud deposits were characteristic on the eastern margins and at the southern end. Figure 3 illustrates the configuration of the bay in the early 1800's and, in fact, until 1888, when the first dredging operations were conducted. The bay is about 15 miles long and varies in width from ¼ to 2½ miles. The surface area is about 18 square miles and the volume approximately 300 million cubic yards.

Two or more earthquake faults are believed to pass through the San Diego region: The Rose Canyon Fault and the La Nacion Fault, in the immediate vicinity, and the Elsinore Fault, 40 miles northeast of San Diego. Geologists believe that these faults are still active and that a major earthquake will occur in the San Diego Bay area in the near future. In fact, the plotted epicenter of an earthquake of 3.5 Richter magnitude that occurred in 1964 was in the middle of the central part of San Diego Bay (Von Hake and Cloud, 1966).

South San Diego Bay is bordered by a flat lowland with little radical difference in elevation. Alluvial deposits predominate to the south and southeast, and foothills begin rising three to four miles inland. To the east of the bay the lowland extends only about a mile and a half inland before it beings to rise gradually to a mesa of Pliocene rock. On this mesa, which ranges in elevation from 200 to 400 feet above sea level, rests most of what is now the city of San Diego. The northern edge of the bay presents a different picture. The flat lowland is constricted to a narrow strip, through which the San Diego River once flowed, and is bordered by Point Loma, which is formed by an extension of the Pliocene mesa that juts to the southwest.

Tides in San Diego Bay are of the mixed type with a marked variation between the two highs and the two lows that occur every day. The difference between the mean higher high water level (MHHW) and the mean lower low water level (MLLW) is 5.63 feet, with an extreme range of 9.5 feet. The area of the bay is 446,222,100 square feet at MLLW and 476,444,300 square feet (including mud flats) at MHHW. The tidal prism, that volume of water which can be contained between any two horizontal planes corresponding to various tidal levels, is 96,405,035 cubic yards. Tidal currents are strongest in the entrance and northern part of the bay. Surface velocities reach 2.9 knots on the ebb tide and 2.2 knots on the flood tide in the north bay, but are greatly reduced in the shallower central and south bay areas (U. S. Army Corps of Engineers, 1973). Figure 4 illustrates tidal flow patterns and relative velocities.

San Diego Bay, situated on a semiarid coast, has an average annual rainfall of 9.69 inches, most of which occurs during the period of November through February. Air temperatures have an annual mean of 61.9°F but during the months of September and October

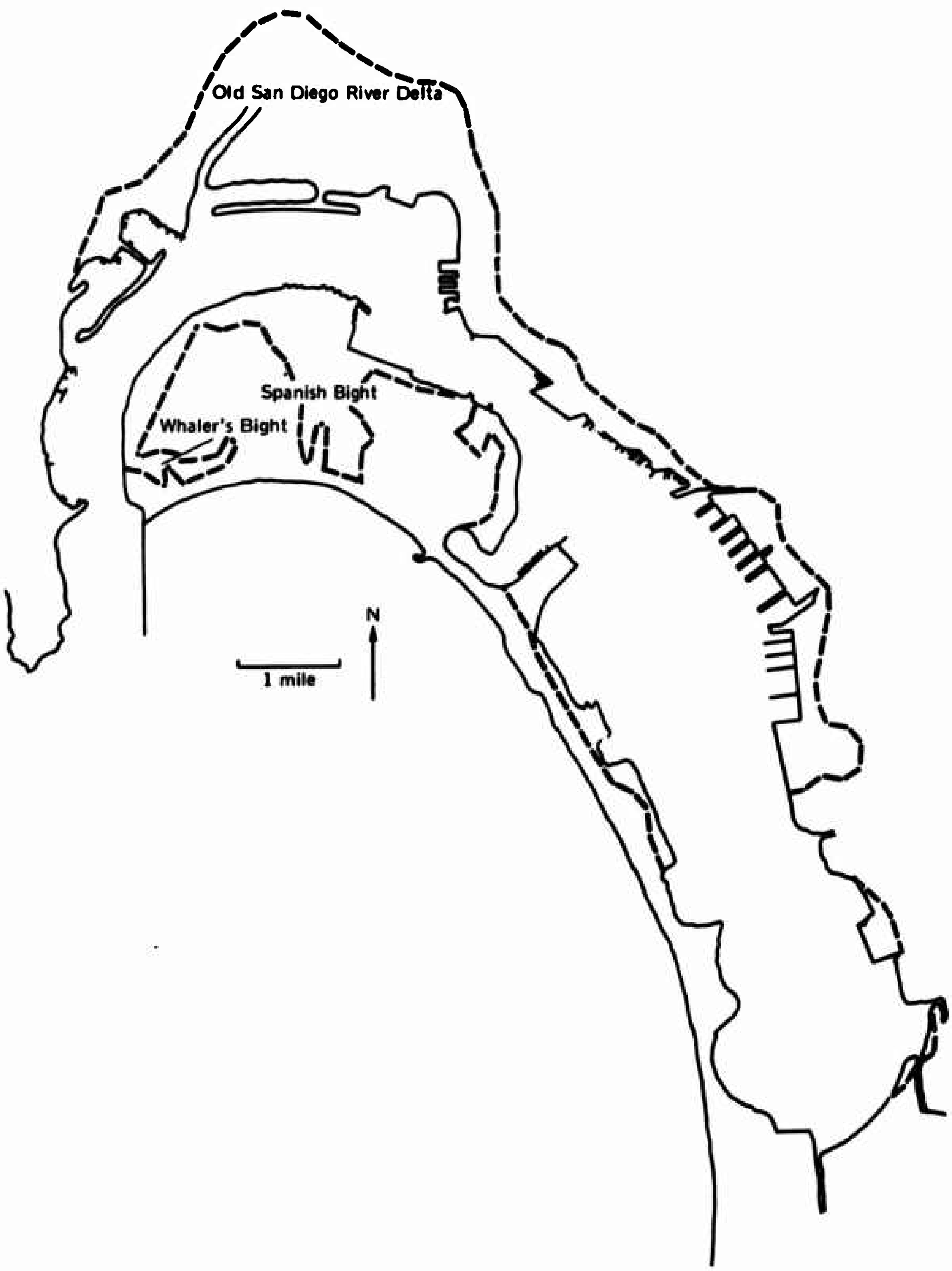


Figure 3. Change in shoreline of San Diego Bay since 1888; solid line = present, dashed line = 1800s. (Redrawn from MacMullen, 1969, and U. S. Army Corps of Engineers, 1973.)

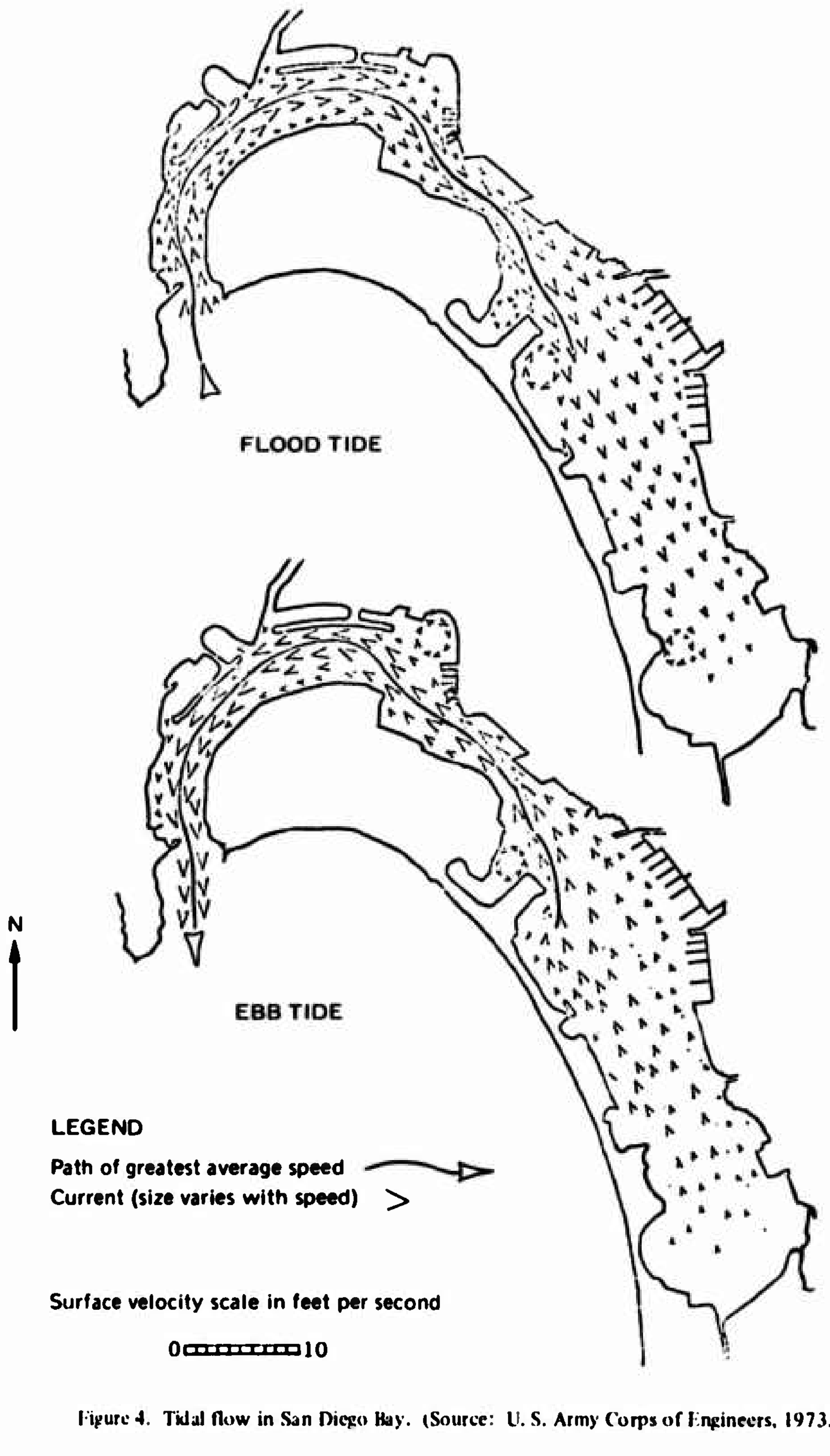


Figure 4. Tidal flow in San Diego Bay. (Source: U. S. Army Corps of Engineers, 1973.)

often exceed 90°F. High temperatures, however, are most often accompanied by very low relative humidity, often below 20 percent (U. S. Department of Commerce, 1972). Strong winds and gales are infrequent, but during the fall and early winter very hot, dry winds, known as "Santa Anas," often blow from the east with considerable force. Figure 5 is a graphic summary of climatological data for the San Diego region.

ALTERED CONDITIONS

General

On September 28, 1542, Juan Rodriguez Cabrillo entered a bay that he named San Miguel, replenished supplies, made appropriate entries in the ship's log as to the existence of the bay, and proceeded with a voyage that was to be fatal. Sixty years later, in 1603. Sebastian Vizcaino entered San Miguel Bay with a force of men and renamed it San Diego Bay. The region remained relatively unpopulated until the arrival of Mexican settlers in 1769. San Diego then became a stopover port for explorers moving up the west coast of North America and for ships working in the Pacific. No major environmental changes took place until after 1846, however, when John Fremont entered the settlement and raised the American flag (MacMullen, 1969). Thereafter San Diego grew quickly and by 1872 had become a city. By 1900 it had a population of 30,000 and was on the way to becoming a major west coast harbor.

In 1888 work in Glorietta Bay started a series of dredging projects that were to alter completely the geographic shape of San Diego Bay, to reclaim approximately 90 percent of the available marsh lands and 50 percent of the intertidal lands, and which are continuing on a large scale today. Figures 6 and 7 illustrate the portions of the bay and marsh lands that have been dredged or reclaimed. Figure 8 shows the areas recommended by the U. S. Army Corps of Engineers for dredging or landfill sometime in 1974. Figure 9 illustrates the approximate extent to which different types of materials make up the shoreline of San Diego Bay.

The Army Corps of Engineers diverted the San Diego River, in 1875, so that it permanently flows into a channel associated with the entrance to Mission Bay, just north of San Diego Bay. Seventy-six percent of the flow of the remaining rivers emptying into the bay, the Otay and the Sweetwater, which drain a combined watershed of 368 square miles, is controlled by storage reservoirs. Underground water supply to the bay is negligible, since the water table is at about mean sea level and is without artesian head. The major effects of these combined factors are that the bay receives insignificant amounts of freshwater and that the amount of siltation caused by stream-carried sediments is negligible. Coupled with this low input of freshwater is a relatively high rate of evaporation, averaging 62.4 inches per year (U. S. Navy, 1950). Consequently, salinities normally range from 33 to 35 parts per thousand, with the higher values occurring in the south bay.

Water temperatures in the northern portions of the bay correspond very closely with the temperatures of coastal waters, 57°F to 75°F. Temperatures in the southern part of the

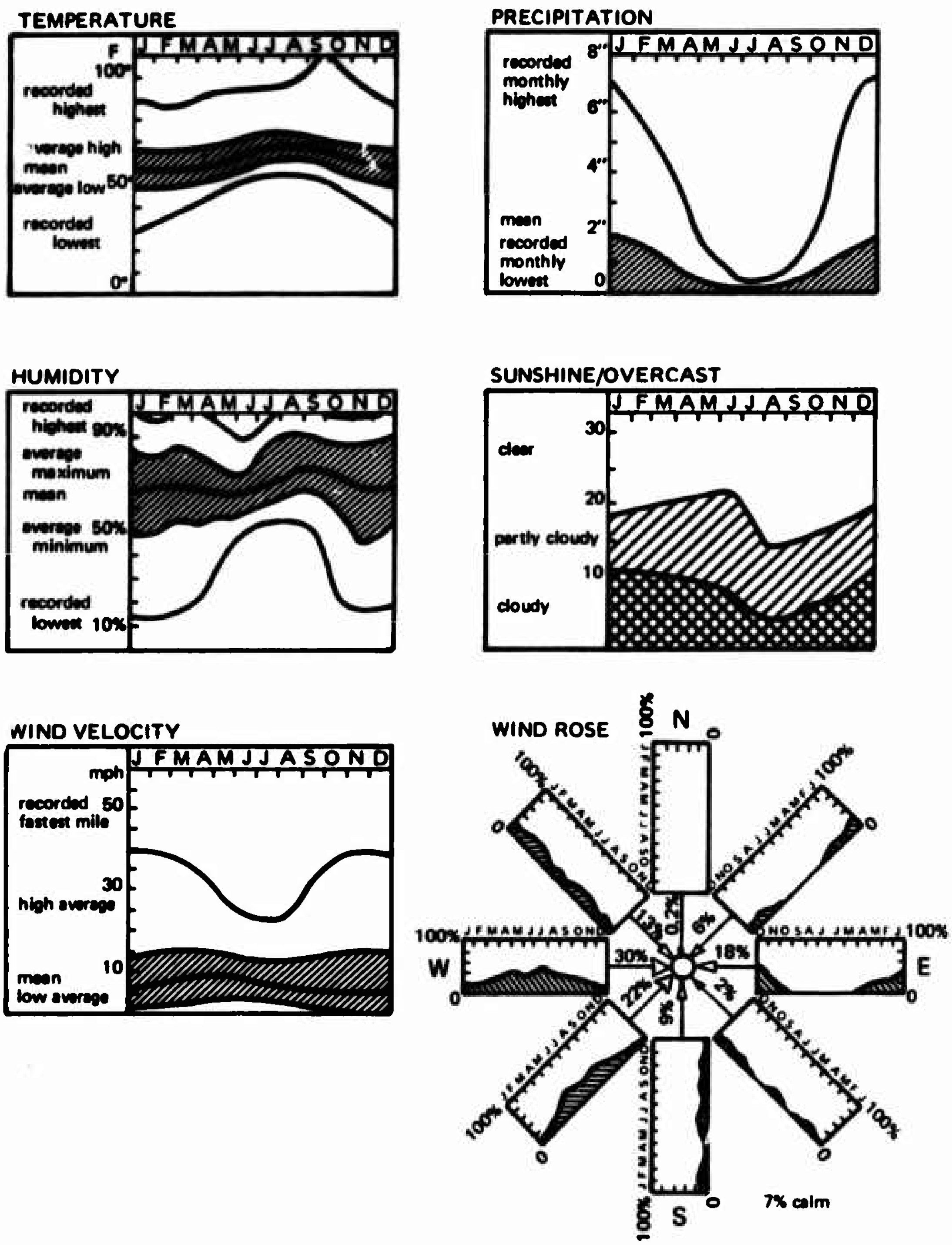


Figure 5. Climatological data for San Diego region. (Source: San Diego Unified Port District, 1972.)

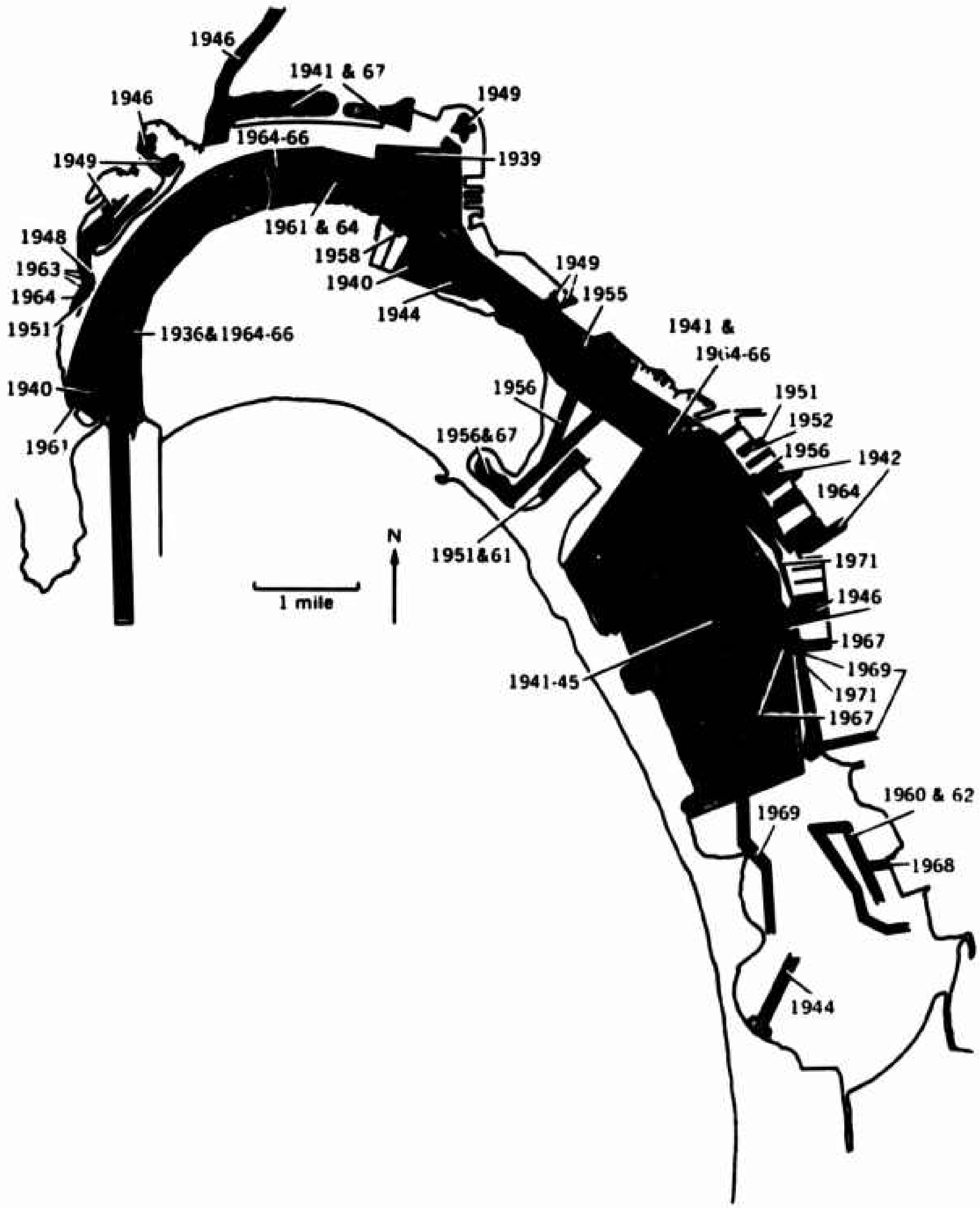


Figure 6. Dredging in San Diego Bay, 1936-1971. (Source: San Diego Unified Port District, 1972.)

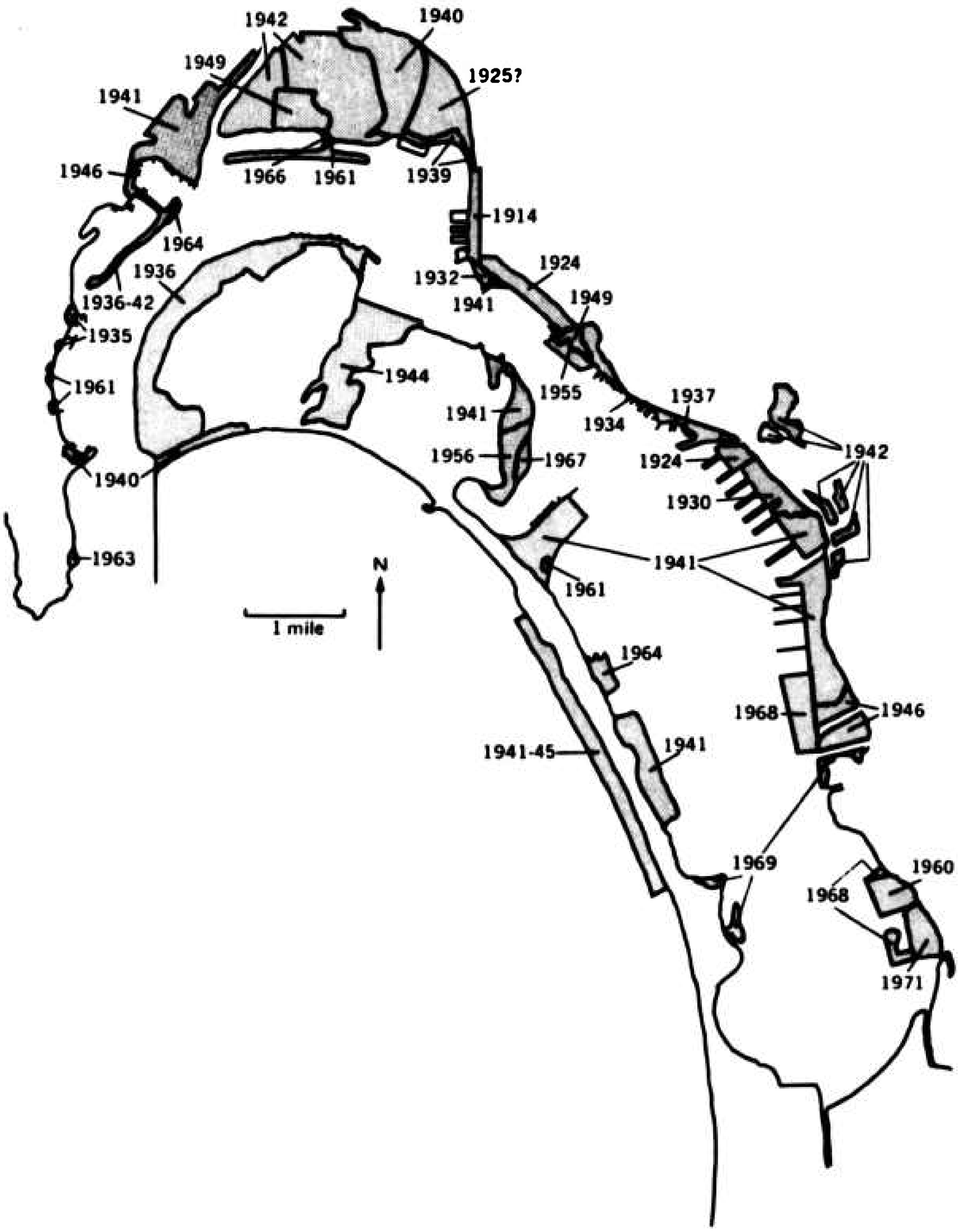


Figure 7. Landfill in San Diego Bay, 1914-1971. (Source: San Diego Unified Port District, 1972.)

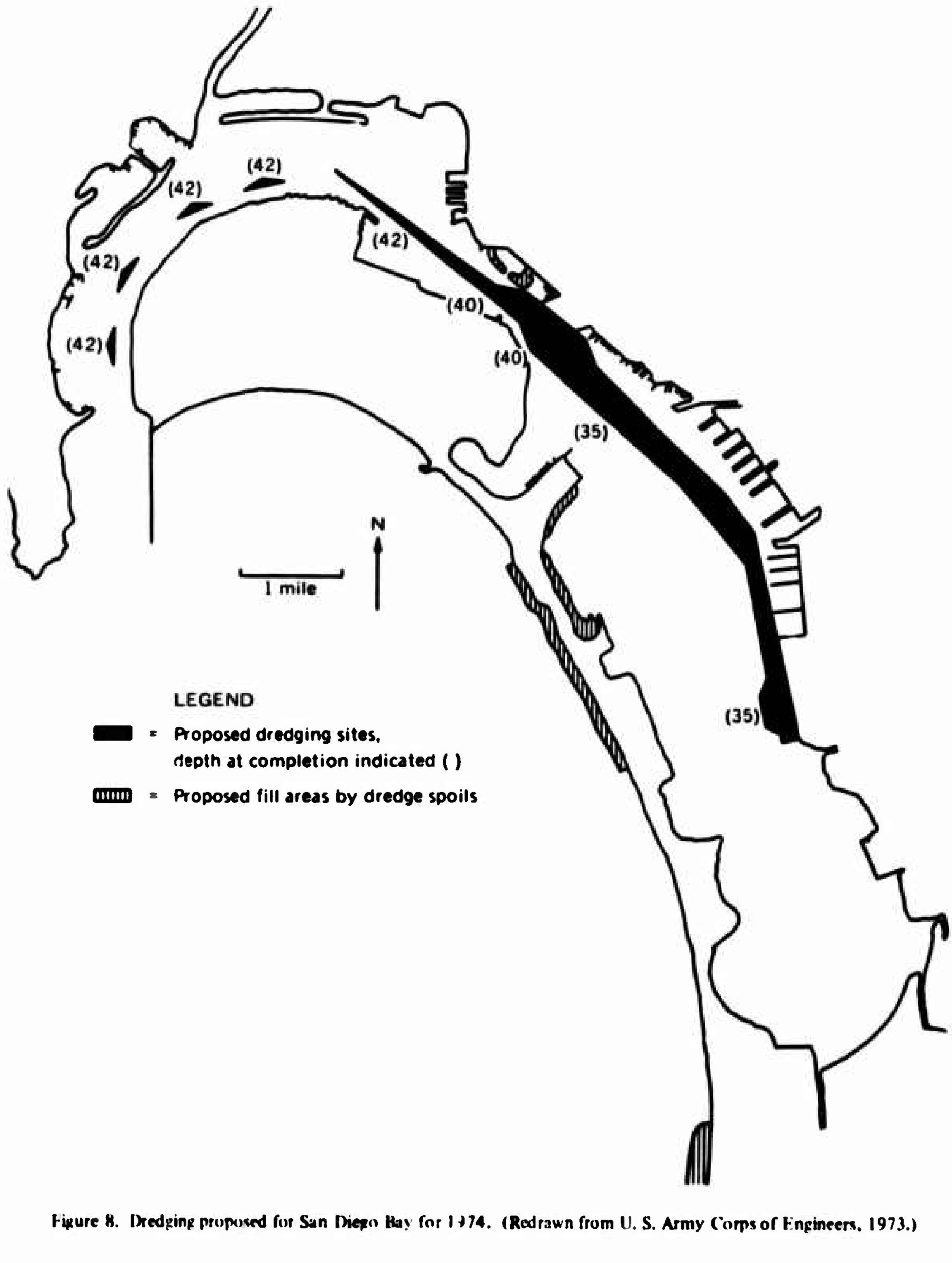


Figure 8. Dredging proposed for San Diego Bay for 1974. (Redrawn from U. S. Army Corps of Engineers, 1973.)

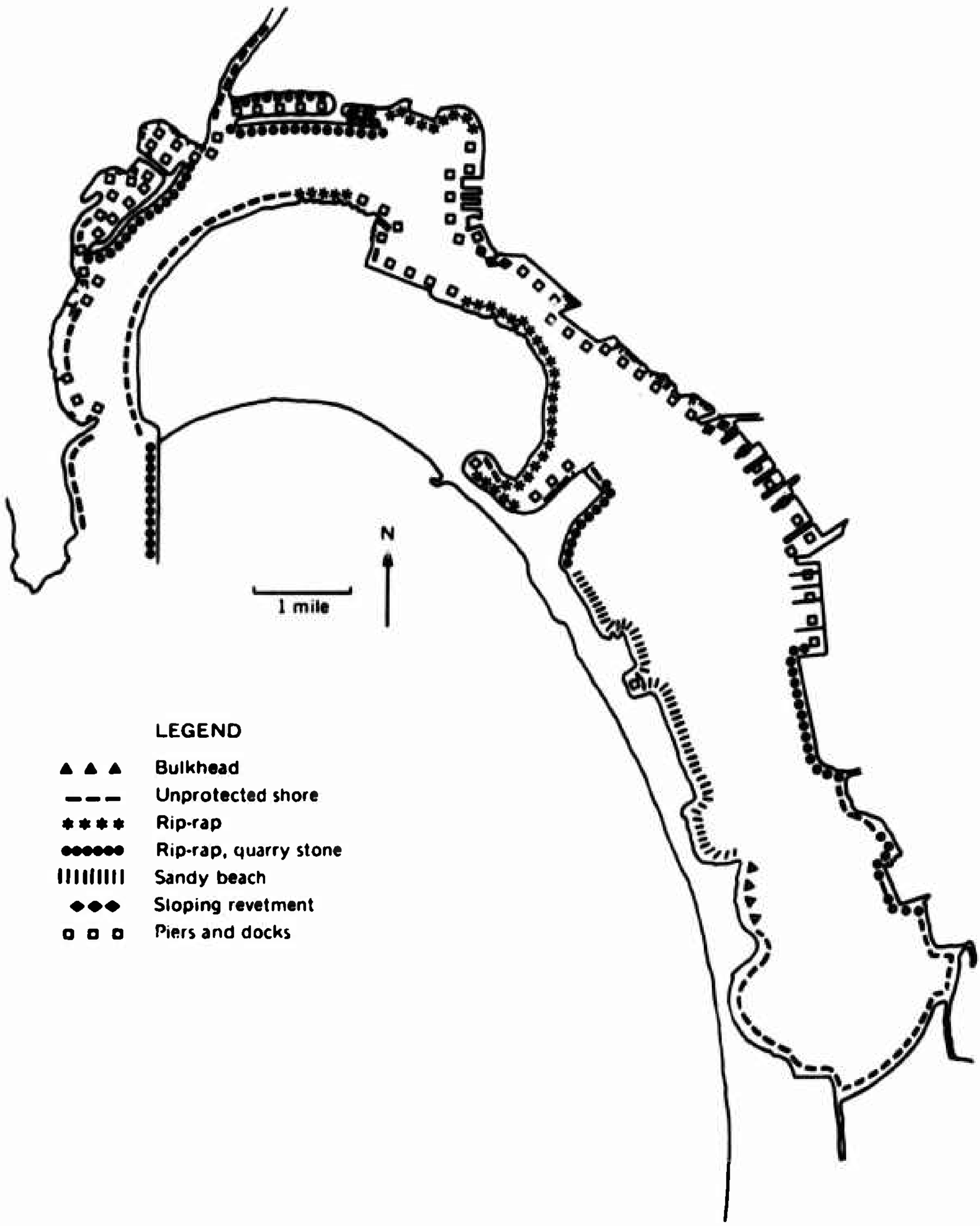


Figure 9. Shoreline materials of San Diego Bay. (Redrawn and revised from San Diego Unified Port District, 1972.)

bay average 3.5°F higher than in the northern part. Differences of as much as 12°F have been attributed to the shallow depths and reduced circulation of the south bay and to the discharge of cooling water from the San Diego Gas and Electric Company's power plant.

Southern California, for the most part, exhibits a littoral transport of beach sands in a southerly direction. But, because of an eddying of the coastal current created by the shoreline of Point Loma, the net transport of sand in the Imperial Beach and Silver Strand area is northward. Historically, the sand transported in this way was replaced by sand that moved north after entering the ocean from the Tiajuana River. Since the damming of the river in 1937, however, this replacement sand has not been available, and the northern beaches have undergone severe erosion. Even though 28,300,000 cubic yards of dredge spoils have been placed on the beaches since 1940, studies indicate that from 1.4 to 2.1 million cubic yards are being moved annually by current and wave action into offshore waters and are permanently lost to the littoral system (Inmann, 1973). Figure 10 illustrates this littoral movement and the accretion of sand in offshore areas.

Local weather conditions have also been altered because of urban development. A layer of cool air, laden with emissions from industrial complexes, automobile exhausts, and aerosols due to urban activity, is often trapped beneath a layer of warm air. It has been well documented that the residue in the cool air mass, called "smog," contributes directly to pulmonary diseases, eye problems, and various other ailments. During 1970 at least one of the six federal air-quality standards was exceeded on 286 days, and according to the San Diego Air Pollution Control Board the region has a greater potential for health-damaging air pollution caused by temperature inversions than Los Angeles or Orange counties. Appendix B gives federal and state regulations for the control of air emissions in the San Diego region.

Water Quality

The San Diego office of the California Regional Water Quality Control Board, the Environmental Protection Agency (formerly the Federal Water Pollution Control Administration), the U. S. Navy, the Lockheed Ocean Laboratory, the San Diego Unified Port District, research projects at local universities, and other sources have all, at one time or another, compiled data concerning the water quality of San Diego Bay. These data are reviewed in this section and summarized in appendix C. Appendix D gives the water-quality control regulations of the state of California.

The first sewage disposal system in San Diego was installed in 1887 and had its outfall offshore from the foot of Market Street. By 1941 nine outfalls emptied into the bay from San Diego, with others serving Chula Vista, National City, Coronado, and several military installations. In 1943 a sewage treatment plant was placed in operation, but even though it was expanded in 1950 it remained almost continuously overloaded. By 1960 most of the bay had been quarantined and posted by health authorities to prohibit uses entailing bodily contact. By 1963 sludge deposits from the treatment plant outfall were seven feet deep and extended 200 yards out from and 9000 yards along the shore. Dissolved oxygen concentrations

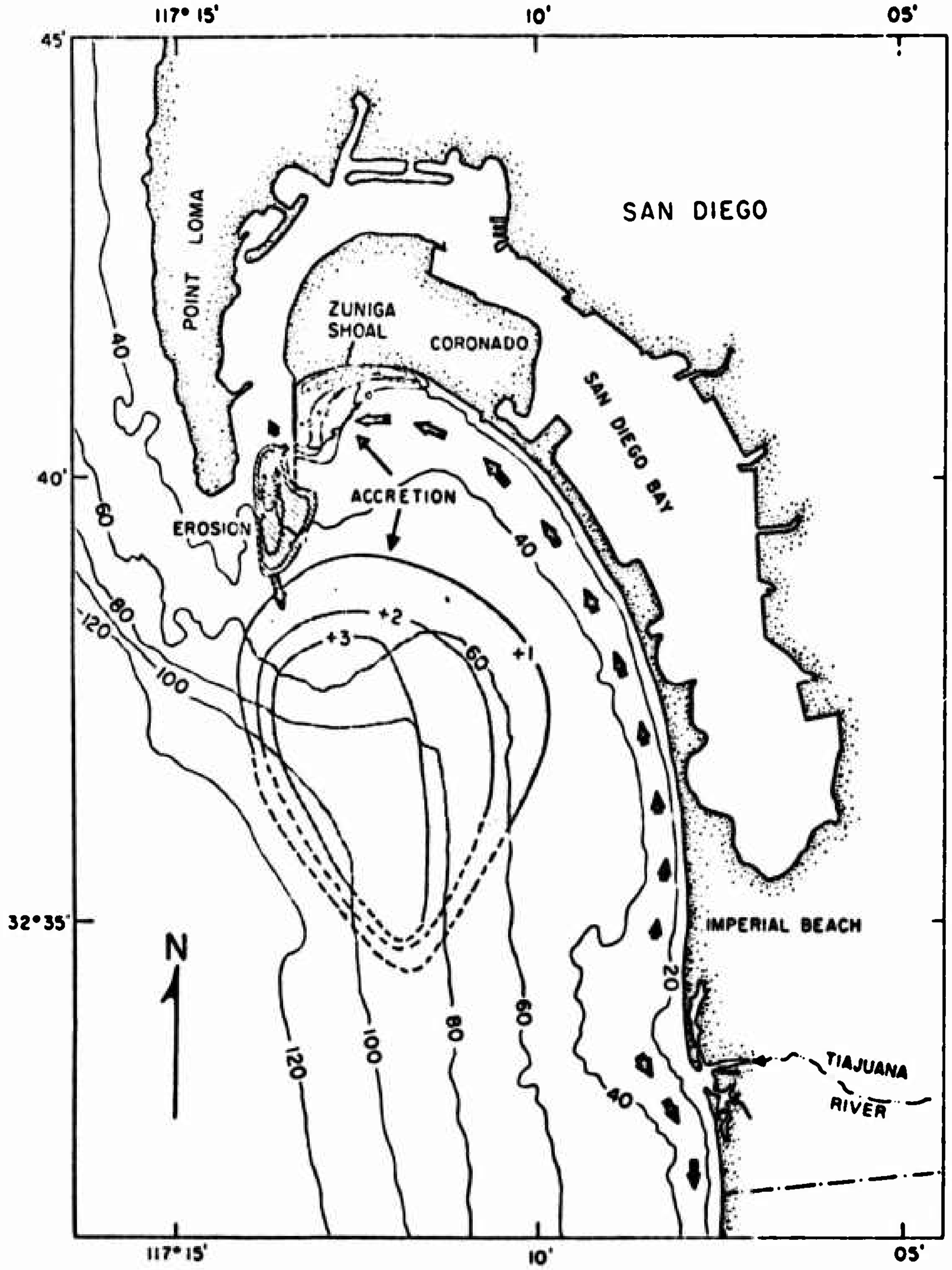


Figure 10. Silver Strand littoral cell, showing the Tiajuana river as the former source of natural sand, the littoral transport paths north along the Silver Strand, and the deposition areas; the final deposition area is the offshore region indicated by the isolines determined by comparing surveys of 1923 and 1934. (Source: Inmann, 1973.)

in the central and south bay were less than 4 parts per million, and turbidity of the water restricted visibility to less than 4 feet; bait and game fish had virtually disappeared.

The San Diego Metropolitan Sewage System, which has an open ocean outfall, was placed in operation in August 1963, and by February 1964 all domestic sewage discharges had been eliminated from the bay. In the period since 1963 dissolved oxygen values have risen to an average of more than 5 parts per million, and visibility has increased to more than 8 feet. Coliform counts now meet federal standards for water contact sports (less than 1000/100 mililiters). Plankton blooms are virtually nonexistent, and sludge deposits have diminished so greatly that depths of more than 12 inches are seldom encountered.

Development of San Diego as a commercial port and an industrial complex has progressed rapidly since the city was established in 1872. The San Diego Unified Port District was formed in 1963 and has contributed significantly to efficient planning for the use of San Diego Bay. The presence of such diverse industries as aircraft design and development, tuna canning, kelp processing, electrical generation, and shipbuilding has, however, resulted in large amounts of material being discharged into the bay each year. Much of this material is taken up by sediments and concentrated in what are often hazardous amounts. Studies conducted recently (Federal Water Pollution Control Administration, 1969; U. S. Army Corps of Engineers, 1973) have shown that many sediment samples contain significant amounts of volatile solids, mercury, lead, zinc, oil or grease, and Kjeldahl nitrogen. These amounts often exceed those allowed under the Environmental Protection Agency's criteria, given in appendix E, for dredge spoils to be disposed of in fresh or marine waters. The least contaminated parts of the bay were found to be near the entrance and the southernmost end. Appendix C includes a summary of some of the data on sediment content.

The San Diego office of the California Regional Water Quality Control Board requires that any concern wishing to discharge industrial materials into San Diego Bay file a formal request for authorization. As of August 1973 only ten companies held such permits. These permits are for the discharge of brine water, cooling water, and fish thawing flume water, totaling 760,884 million gallons per day. Presumably, other companies with materials to discharge have found other means, such as tying into the Municipal Sewage System, for their disposal. Figure 11 lists the companies authorized to discharge industrial products into San Diego Bay and shows the location of each discharge site.

In fiscal year 1970-1971, 1.4 million tons of cargo, valued at 273 million dollars, passed through the Port of San Diego. This cargo represented the approximately 600 ships, not including fishing boats, that used the port's facilities during this period. In 1968 the San Diego tuna fleet landed marine catches totalling about 70 million pounds and valued at 11.5 million dollars. At present there are about 3000 small craft permanently berthed in San Diego Bay, and new slips being constructed at Harbor Island will soon allow berthing of 4300 boats. It is estimated that 500,000 people participate in water-oriented recreational activities in San Diego Bay each year.

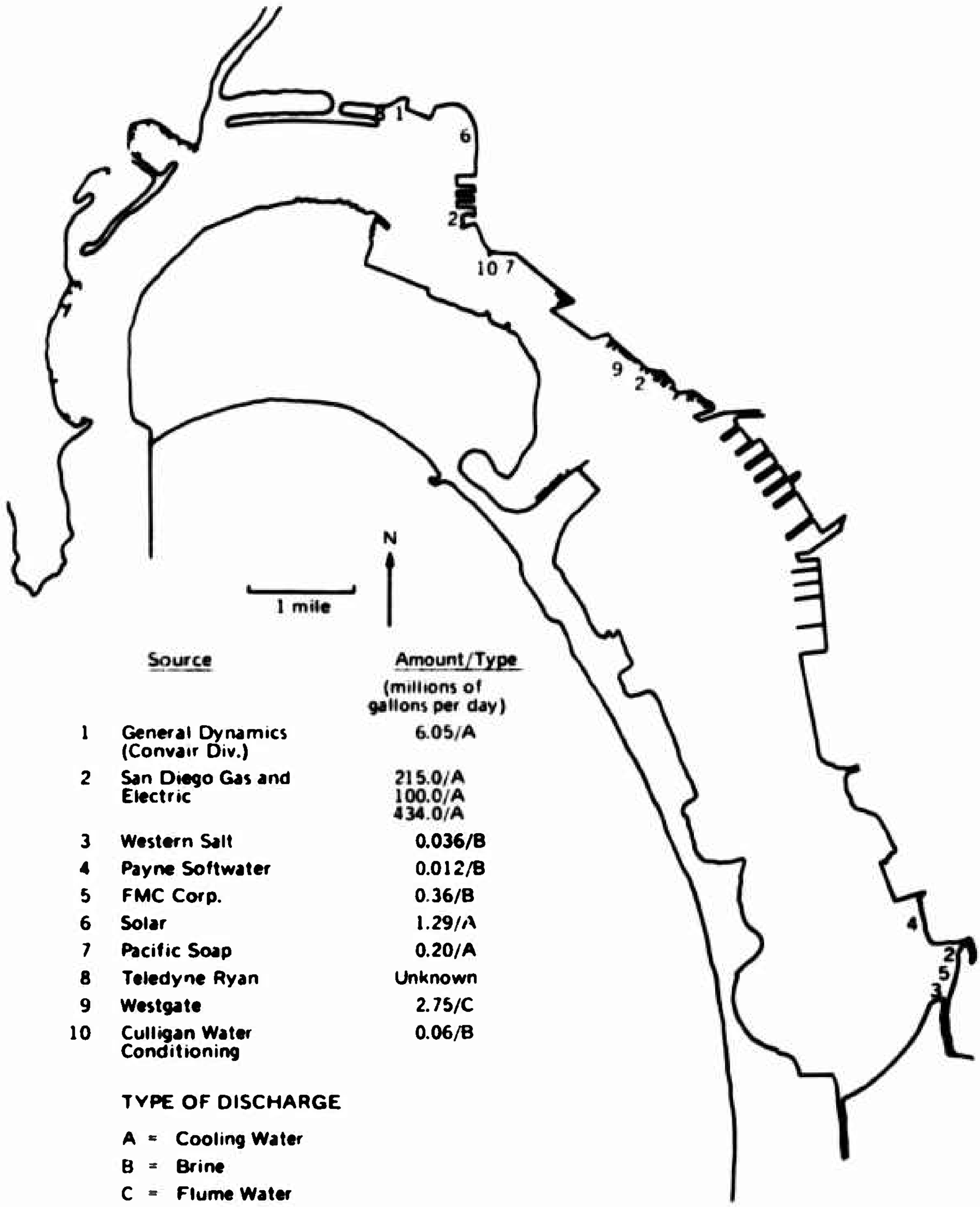


Figure 11. Civilian industrial effluents in San Diego Bay. (Source: California Regional Water Quality Control Board, unpublished data.)

Navy Role

Essentially all sewage discharges into San Diego Bay were stopped by February 1964 and vessels became the sole source of sewage discharged into the bay .... Except for oil discharges from ships, all industrial pollution of the bay has been controlled .... Ships operated by the Navy are the principal sources of vessel wastes, including sewage and oil, discharged into San Diego Bay.

These statements were paraphrased from the minutes of a public hearing conducted on January 24, 1972, and entitled "The Matter of Discharges of Sewage and Oil to San Diego Bay from U. S. Navy Vessels" (California Regional Water Quality Control Board, San Diego Region, 1972a). They make necessary a section of this report concerned primarily with the Navy's role in the bay.

San Diego plays host to approximately 7 percent of the total U. S. Navy forces ashore. This 7 percent comprises 140,000 active duty personnel, 200,000 dependents, 25,000 retired personnel, and more than 24,000 civilian employees. The total makes up more than 25 percent of the population of San Diego County. To these numbers must be added the number of shipboard personnel in port at any one time, which averages 26,000 (Naval Civil Engineering Laboratory, 1972 a) and which could reach a maximum of 36,000 (Federal Water Pollution Control Administration, 1969). The Navy contributes approximately 1.2 billion dollars annually to the economy of San Diego, city and county.

Table 2 lists the average number of ships in port on any day in 1967, 1972, and 1973 (through July). Mr. J. R. Lanne, Assistant Berthing Officer at the Naval Station, states that, because of the closing of major facilities on the west coast, the average number of ships berthed at the Naval Station will gradually increase to about 60 per day by 1976.

It is estimated that 400,000 gallons of raw sewage enter San Diego Bay each day from ships berthed at the Naval Station and North Island. Equipment to allow shipboard wastes to be transferred ashore for disposal has been designed, however, and is now being installed on a number of ships. With the completion of current construction of dockside and shipboard facilities it will be possible to eliminate about 55 percent of the Navy's discharges into the bay. It should be noted that tenders and submarines berthed at the Submarine Support Facility at Ballast Point are already discharging their sewage into the municipal system, as is also the USS KLONDIKE, support ship for the Inactive Ship Facility. By 1980 all discharge of sewage into San Diego Bay from Navy ships will be eliminated.

Oil slicks can be seen on the water of San Diego Bay on any day of the year. Since there are no petrochemical plants or refineries nearby, the slicks are largely the result of the fueling, internal fuel transfer, and bilge pumping operations of ships and boats. The following rationale extracted from the minutes of the public hearing quoted above is noteworthy in this context:

All other factors being equal, the possibility for an accident or spillage to occur is directly related to the number of times a given volume of oil is transferred. Using fuel oils as

an example, the following comparisons indicate the need for close control of fuel transfer by the Navy commands in this area. (All numbers are rounded off for convenience.)

Agency	*Transfers*	*Volume (tons)*	*Relative Volume*
Commercial ship bunkering	*Ship to shore/ shore to ship*	*30,000*	*2 x 30,000 = 60,000*
San Diego Gas & Electric Co. Power plant	*Ship to shore*	*400,000*	*1 x 400,000 = 400,000*
Navy Fuel Depot	*Ship to shore/ shore to ship*	*200,000*	*2 x 200,000 = 400,000*
	Ship to shore/ shore to yard oiler/ yard oiler to ship	*100,000*	*3 x 100,000 = 300,000*

Although the absolute tonnage of fuel oil delivered to the San Diego Gas and Electric Company is the largest, because of the difference in distribution and usage, on a relative basis, the Navy has a larger tonnage to deal with. The relative difference would be even larger if internal transfer operations aboard ship were considered since only the unloading tanker would be affected in the one case and at least one loading vessel in addition to the unloading tanker in the other.

The greater exposure of the Navy to spills is more easily seen when external transfer operations are considered. Using the T-2 class tankers (15,000 T capacity) to bring fuel oil to San Diego and delivering one-third of the Navy fuel by yard oiler (1000 T capacity), which must be loaded and then unloaded, the number of transfers are compared.

	Delivery Shiploads (tons/loads)	*Transfers*
San Diego Gas & Electric Co.	*400,000 ÷ 15,000 = 27*	*27 x 1 = 27*
Navy	*300,000 ÷ 15,000 = 20*	*20 x 1 = 20*
	Distribution	
Navy	*100,000 ÷ 1,000 = 100*	*100 x 2 = 200*
		TOTAL 247

Based upon the preceding comparison, the Navy would be responsible for 220 of the 247 transfers. The Vessel Pollution Study – San Diego Bay, California (FWPCA, 1969) attributed 90 to 95 percent of all vessel activity in San Diego Bay to the Navy, and it can be seen that [the] proportion of fuel oil handling by the Navy is at least as great.

Of the 262 oil spills that occurred in San Diego Bay between January and mid-December 1971, as reported by the U. S. Coast Guard or the Harbor Police, 113 were attributed directly to U. S. Navy activities and 55 others implied Navy involvement. Of the 275 oil spills reported for 1972, 132 involved amounts of more than about three gallons, and of these 93 were attributed to the Navy. It may be noted, however, that the worst spills to occur in 1972 were attributed to civilian sources as follows:

April	1400 gallons	Campbell Machine Co.
May	3400 gallons	National Steel and Shipbuilding Co.
July	3000 gallons	drainage from Switzer Creek

In 1965 the Navy was the only agency using the bay that cleaned up oil spills, expending 65,000 dollars to do so in that year alone. Federal regulations now require immediate clean up by any or all concerns involved. Intensive training programs have been initiated by the Navy to improve the job capabilities of fuel handlers; design criteria for fuel handling hardware are being updated to help eliminate leaks and overflow problems; and oil spill recovery gear is continuously being developed. By these means fewer spills will occur, and those that do will be handled more efficiently.

Table 3 presents a summary of the discharge sources and effluent material from each of the major Navy installations in the San Diego region. Past construction has decreased and current projects will further reduce the volume of these discharges. Industrial waste discharges from North Island were eliminated in September 1973; work is in progress to divert Public Works Center industrial wastes to the sanitary sewer; and plans have been approved to relocate old pipelines at the Naval Supply Center's fuel farm.

BIOLOGICAL FACTORS

Several biological studies of San Diego Bay have been conducted, with the emphasis on benthic communities. The reader is referred particularly to the following: Parrish and Mackenthum, 1968; Ford, 1968 and 1970; and U. S. Army Corps of Engineers, 1973. This section summarizes some of the studies previously conducted and presents original data concerning the fishes of San Diego Bay.

Fecal and total coliform bacteria contamination of the bay has been on the decline since 1963 when the Municipal Sewage System was placed in operation, removing the large sewage load from bay waters. A study conducted by the Federal Water Pollution Control Administration (1969) over a 15-month period yielded the following results: (1) Median

total coliform levels greater than 200/100 milliliters (ml) were confined to a relatively small area of the bay; (2) Total coliform counts of over 1000/100 ml were limited to pockets along the eastern shore; (3) The maximum bacterial density encountered was 8200/100 ml and was found within the Naval Station; (4) Of 157 sampling stations, 30 had a total coliform density of 1000/100 ml or more in at least one sample; (5) Fecal coliform levels were generally low, but 28.7 percent of the sampled stations had densities in excess of 200/100 ml.

Results of the three coliform samples taken at each stations during the present survey are shown in figure 12 together with some of the results of the above study. A close correlation is observed in the regions of highest contamination; as can readily be seen, however, occasional high values also occurred in regions away from the main industrial sites. The results of the present survey, including the dates and times at which the samples were taken, are also presented in table 4.

Parrish and Mackenthun (1968) have concluded that sediment samples containing less than five kinds of organisms or more than 200 polychaete worms per square foot are indicative of polluted conditions in San Diego Bay. They further categorized various sections of the bay in the following terms:

1. Naval pier area. Bottom organisms were predominantly polychaete worms, an indication of moderate-to-severe organic pollution.

2. Channel offshore from the naval pier area. Covered with 33 inches of old sludge that supported 1300 polychaetes per square foot.

3. Glorietta Bay. Thin covering of sludge that supported only 22 polychaete worms per square foot and one other kind of organism, an indication of moderate-to-severe pollution. Samples taken far inside the bay contained no sludge but were slightly polluted with organic material that supported 462 polychaetes per square foot and only three other kinds of organisms.

4. Bottom north of Tenth-Avenue Marine Terminal. Covered with sludge and oils that were toxic to most benthic organisms.

5. South Bay (San Diego Gas and Electric Company zone of mixing). Heated cooling-water caused an increased growth and death of microscopic organisms that settled to form deposits of organic material. Over 1400 polychaetes per square foot and one species of pollution-tolerant snail existed in the effluent channel.

6. Carrier basin. Contained approximately 38 inches of stable sludge supporting both polychaetes and molluscs.

7. Harbor Island Bay. Contained organic debris that supported over 6000 polychaetes per square foot, a result of moderate organic pollution.

8. North Bay. Most of North Bay contains pollution-sensitive organisms that reflect the unpolluted conditions existing at the harbor entrance.

Micromolluscs, molluscs represented by shells less than 10 millimeters in greatest dimension, include juveniles of species which will eventually be of greater size and adults of species as small as 0.5 millimeters. They appear to represent most of the spatial and trophic

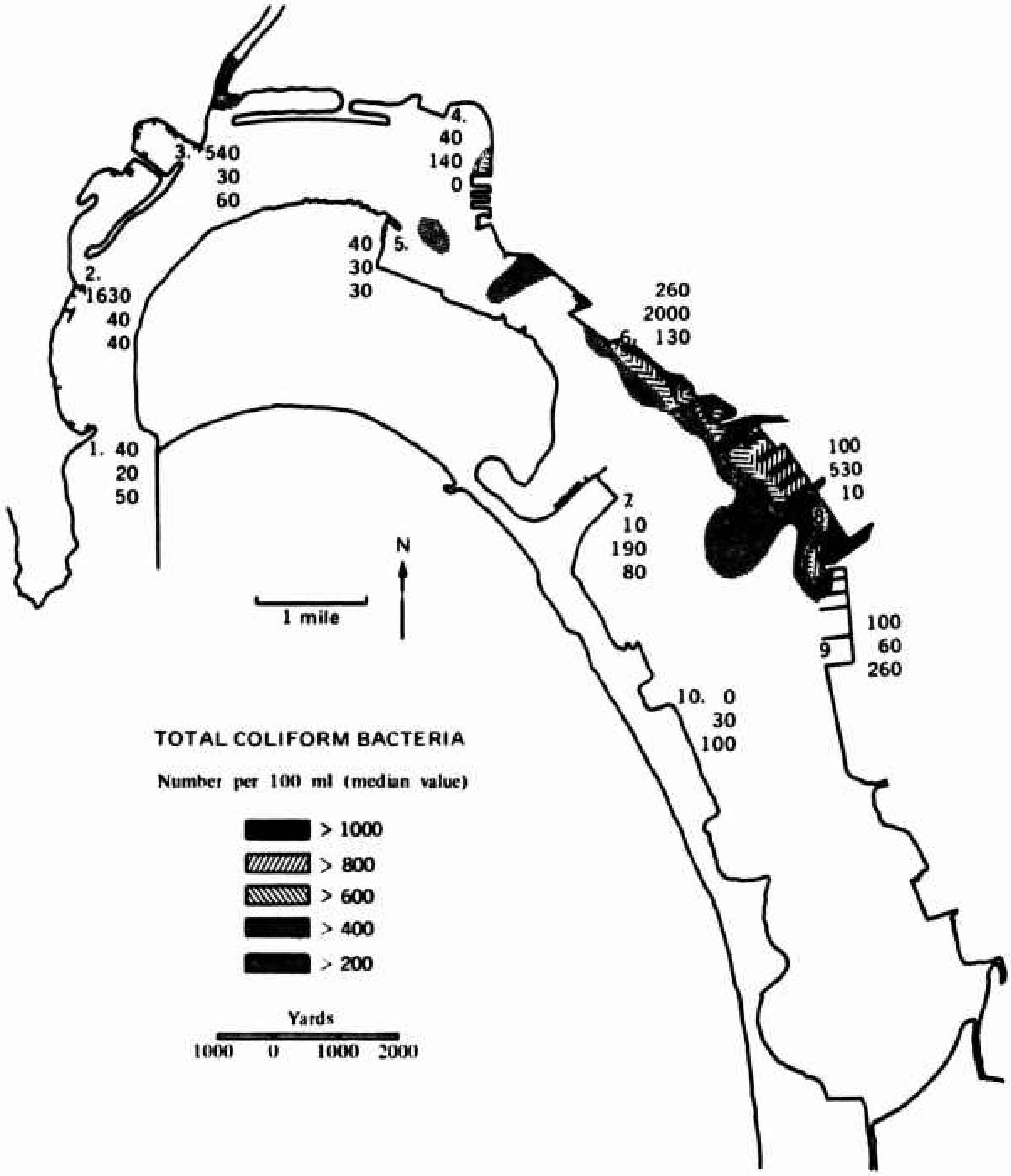


Figure 12. Distribution of coliform bacteria in San Diego Bay in 1967 (Source: Federal Water Pollution Control Administration, 1969) compared with sample data collected during Proximate Survey.

components of molluscan communities in the immediate vicinity of a sample; that is, benthic, epifaunal, and sessile molluscs (Kay, in Evans, 1972). Although recent sediment sampling studies have been conducted in San Diego Bay, they have been concerned for the most part with physical-chemical parameters and not biological data. The sediment samples taken in the present survey, as shown in table 5, revealed a distinct scarcity of micromolluscs at stations exposed to chronic industrial or shipboard wastes. Stations 1, 2, and 7, which are either near the entrance to the bay or in the south bay, have higher populations. A continuing biological sampling program conducted by the Naval Undersea Center in San Diego Bay will include analysis of the total organismic content of benthic samples. This future sampling should allow between-station comparisons and evaluation of the use of such organisms as micromolluscs for assessment of benthic conditions.

The San Diego office of the California Regional Water Quality Control Board reported in 1966 that only one plankton bloom had been observed in San Diego Bay since the Municipal Sewage System went into operation in 1963. Even though several small blooms have occurred more recently, they have been attributed to local disturbances, such as dredging, and have not been well documented. The Lockheed Ocean Laboratory (Benson, 1972) and the San Diego Gas and Electric Company (Ford, 1968) have conducted periphyton investigations that, when combined with "Ecology of the Microbiota of San Diego Bay, California" (Lackey and Clendenning, 1965), provide substantial information pertaining to the plankton of the bay.

In 1892 C. H. Eigenmann published "Fishes of San Diego, California," in which he listed 62 species known to inhabit San Diego Bay. Since that time the number of species in the bay has fluctuated from a probable low about 1964, when water quality was at its worst, to a current value that is probably as high as that recorded in 1892. It is possible that, through the use of scuba and systematic netting and trapping, the checklist of fish species inhabiting San Diego Bay can be significantly increased.

A series of trap and gill net sets conducted during April and May 1973 yielded a total of 38 species of fishes. It should be noted that these sampling methods were selective for the larger fishes and did not collect small, juvenile specimens or small species, such as blennies, gobies, and bait-fishes. Bait-fishes, such as topsmelt, jacksmelt, and anchovy, were apparently almost nonexistent during the early 1960s, but as water quality increases more and more sightings are being reported; the number of predator species feeding on these bait-fishes is also increasing.

Table 6 lists the 38 species collected and presents a constant (k) for each species for computation of specimen weights from given lengths. One important feature of fish growth is the relationship between length and weight; it has been found that for many species weight increases as the cube of the length. This relationship implies that changes in form with age are relatively conservative and that many fishes do not show marked deviation from a fusiform shape. Using this cubic relationship as a rule of thumb, the constants reported in the table were computed by the formula:

$$\text{Weight} = k\,(\text{length})^3.$$

It is anticipated that the use of this formula will allow:

(1) Estimates of weights to be made after estimated lengths have been obtained during diving surveys;

(2) Weights to be computed from fishes whose collection permitted length measurements but, for some reason, not the taking of weights (as in sampling from a small boat, where scale accuracy is severely hampered by water movement; and

(3) Computation of gross weights when commercial catch data are available in numbers and estimated sizes only.

Table 6 presents the length-weight conversion constant in two forms, k_m for length measured in centimeters (yielding weight in grams) and k_e for length measured in inches (yielding weight in pounds). Total or fork length measurements were used for all computations.

Table 7 presents a summary of the catch at each station by sampling method. These data will be of continuing use as seasonal and more intensive sampling are carried out, both as a basis for determining changes, if any, and as an indicator of community or subcommunity structures. Table 8 presents weight and length ranges and means for each species collected.

Black croaker and bonito were by far the most numerous species collected during the two-month sampling period; a total of 1321 black croaker and 397 bonito were taken. Many of the black croaker were sexually ripe and exuded milt or eggs when handled, a fact that correlates well with data previously published on the spawning behavior of the species (Eigmann, 1892; Limbaugh, 1961). Limbaugh reports that larger black croaker (greater than 88 millimeters in length) tend to break away from the main school of smaller individuals and seek more reclusive caves and crevices. It is almost certain that the large number of black croaker taken during the present study was the result of concentrated spawning aggregates in sampling areas, especially in the areas of the bay that receive little ship traffic or offer protective cover in the form of piers. Continued sampling will give more detailed information on localized concentrations and habitat preferences for this species.

Commercial- and sport-landing records for the Pacific bonito imply that there has been an increase in either the availability or abundance of this species off California during the last decade. Studies concerning the biology and life history of the bonito (Godsil, 1955; Klane, 1961; Pinkas, 1961) show that they feed primarily on small pelagic schooling fishes. These factors combined with an increasing number of bait-fishes found inside San Diego Bay probably account for the high number of bonito collected during this survey. The mean weight, 1.4 pounds (621 grams), and the mean length, 15.1 inches (38.4 cm), of the specimens collected place the population of bonito in San Diego Bay during this survey in the one-year age group. The majority were probably spawned in the period from January to May of 1972.

Figure 13 provides a classification of each of the ten sampling stations by the species of fish or fishes that would most likely be collected there during a fish sampling program. The surfperches and croakers, other than the black croaker, extend into the bay generally only as far as station 3. Seventy percent of the corbina, also a croaker, were taken at stations 1 and 2, but an isolated group is also indicated in the south bay around station 10. The

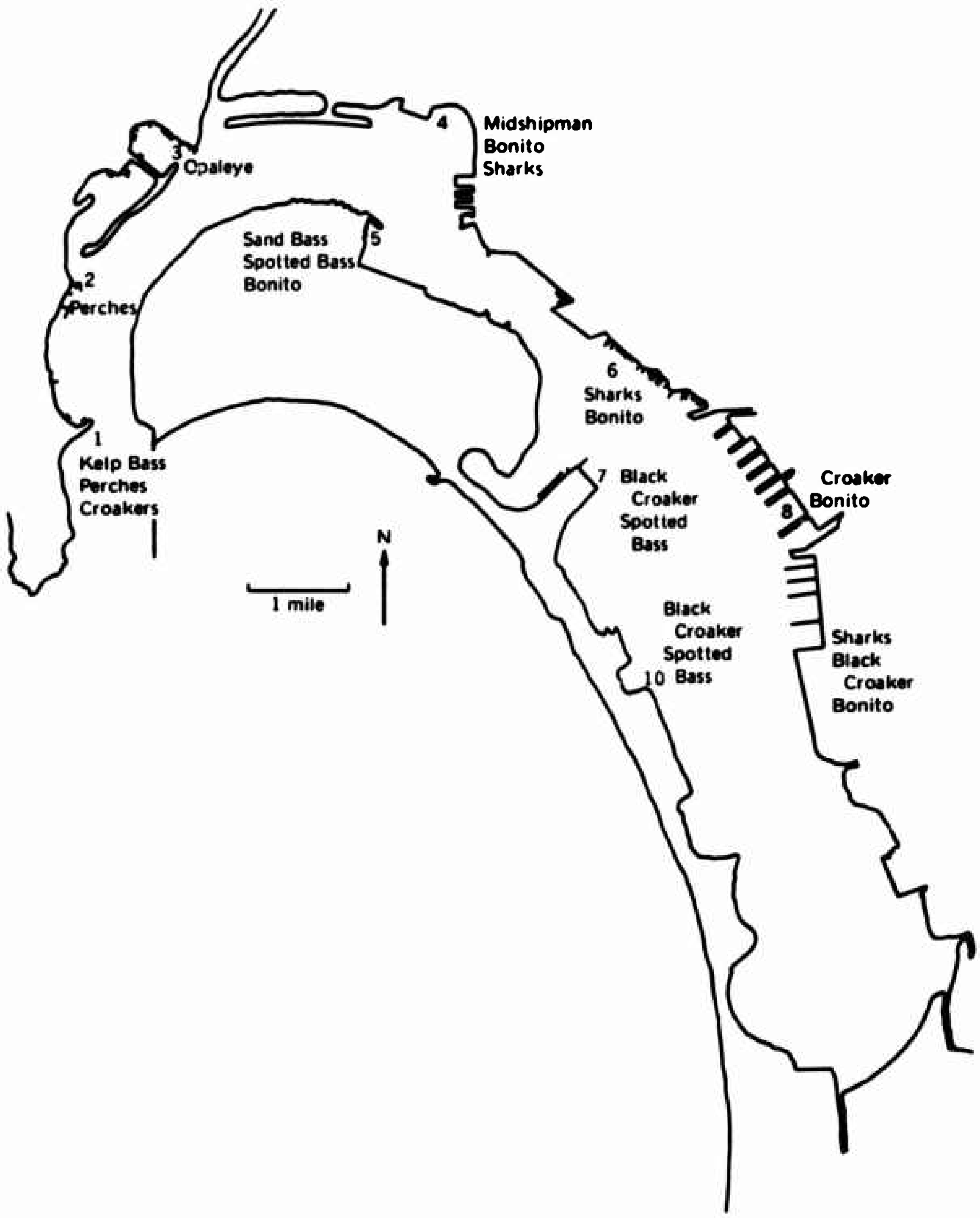


Figure 13. Species of fish most often collected at individual stations during Proximate Survey.

bonito and the sharks were taken, for the most part, at stations on the deeper east side of the bay. Seventy-five percent of the kelp bass were collected at station 1, but 70-75 percent of the sand and spotted bass were taken farther inside the bay than station 5. The black croaker were collected almost exclusively at stations 8, 9, and 10. Table 9 presents a breakdown of the most often caught species by percent by stations. Heavy metal content analysis results for some species of fishes collected in San Diego Bay are presented in Table 10.

Incidental to the collection of fishes by traps and gill nets was the taking of crabs and lobsters. Two species of crab, *Cancer antennarius* and *C. anthonyi*, were collected at various times at all the stations. The spiny lobster, *Panulirus interruptus*, was taken at stations 1, 2, 3, 4 and 5, with substantial numbers being trapped at station 4. A total of 48 male lobsters and 16 female was collected, but, because the catch was released without tagging and because multiple trap and net sets were conducted at each station, an estimate of population density cannot be made. A catch ratio as high as 15 male lobsters to 2 females was observed at station 4, but scuba dives made in the area showed that many large females were tucked away in rock crevices brooding eggs and could not be forced from cover. Spiny lobsters move inshore during their spawning season, March through July, which would account for the numbers of lobsters collected. It is quite probable that females rely on body-stored food supplies during the egg-brooding period and do not actively search for food. This behavior would account for the high ratio of males to females collected in traps. Length, measured from midway between the eye sockets to the rear edge of the body shell, for the males ranged from 2.5 to 5.5 inches (6.4 to 14.0 cm) and for the females from 1.9 to 5.0 inches (4.8 to 12.7 cm). Heavy metal content analysis for spiny lobsters taken from San Diego Bay and offshore waters is presented in Table 10. It should be noted that even offshore specimens have surprisingly high concentrations of mercury.

Underwater dives conducted in December 1972 in the shallow, western side of San Diego Bay and off Santa Catalina and San Clemente islands found piling community structures to be very similar and dominated by the mussel *Mytilus edulis*. Subsequent dives on the deeper, eastern side of San Diego Bay found much sparser piling community structures, with *M. edulis* limited to 2 to 3 foot bands near the surface and with hydroids and tunicates the dominant organisms. Figure 14 illustrates a vertical profile for pilings in San Diego Bay along the western side or near the entrance.

Table 11 presents a cumulative checklist of common strand plants and marine organisms known to inhabit San Diego Bay at some time in their life cycle. The list is a combination of those compiled for this and other reports. It will be helpful in the continued monitoring of environmental conditions in San Diego Bay and will be updated periodically with the results of current studies. A partial list of people and organizations conducting such studies is given in appendix A. Table 12 presents a list of birds that permanently or periodically inhabit the San Diego Bay area.

PILING PROFILES

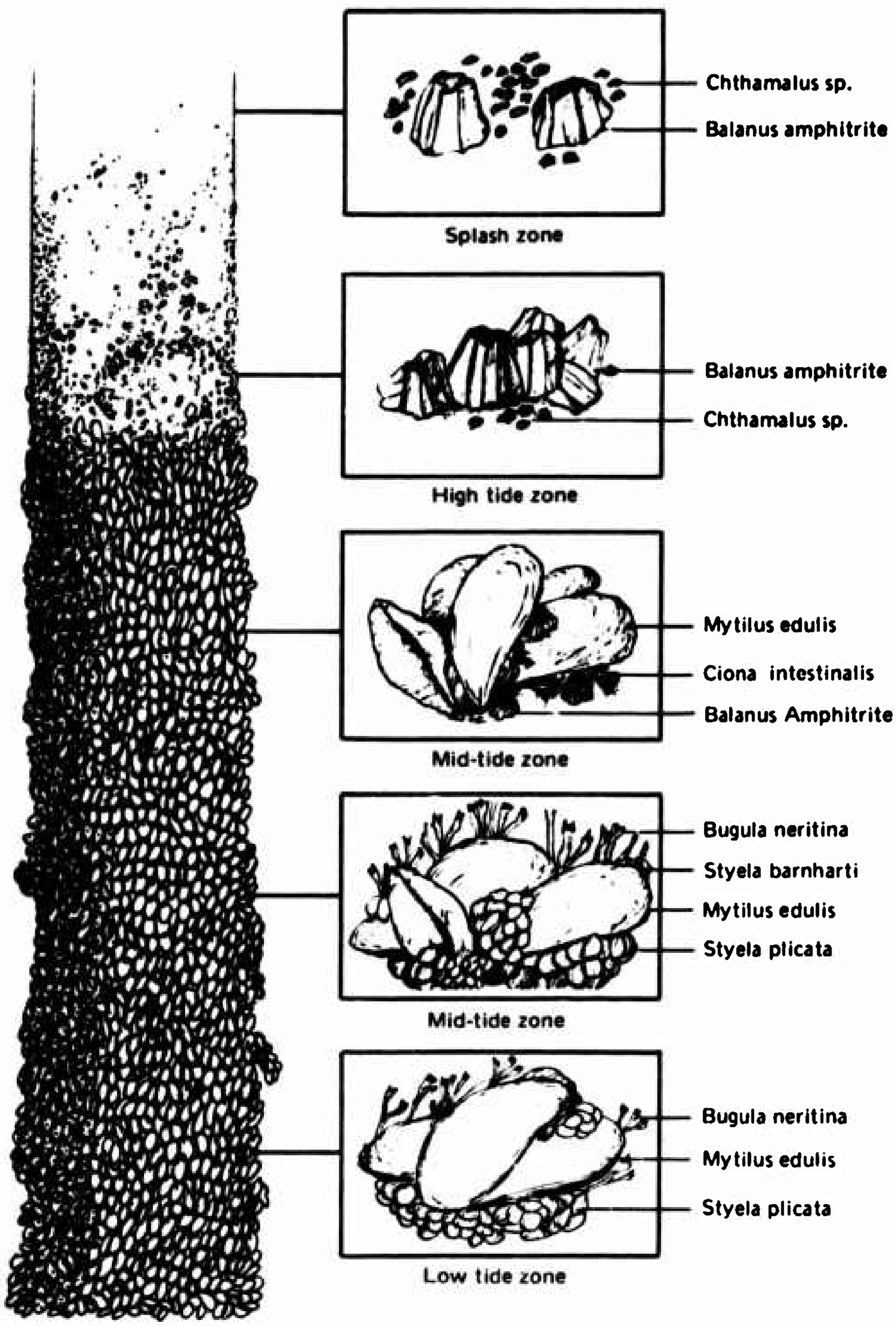


Figure 14. Piling community structure for selected pilings in San Diego Bay.

CONCLUSION

The following major points have been presented in this report as a result of the biological survey of San Diego Bay conducted from December 1972 to June 1973:

1. After a period of dramatically decreasing water quality, San Diego Bay is well on the way to recovery. During the years from 1935 to 1963 most of the bay was quarantined by health authorities to prevent bodily contact uses; algal blooms discolored its waters almost continuously, and bait and game fishes virtually disappeared. Installation of a municipal sewage treatment plant with its outfall in ocean waters off Point Loma, however, has reversed the trend toward declining water quality.

2. Domestic and industrial discharges into the bay have been almost eliminated. The exceptions are discharges of raw sewage from military and civilian vessels and of limited amounts of cooling and thawing waters from industrial plants.

3. The U. S. Navy is concentrating efforts to eliminate the discharge of its wastes into the bay. Almost all naval industrial discharges were eliminated by the end of 1973, and 55 percent of current sewage discharges will be rerouted to the municipal sewage system in the near future. It is estimated that by 1980 the discharge of naval wastes into the bay will be completely eliminated.

4. A number of marine organisms, including commercially and recreationally important species, are abundant and reproducing naturally in the bay. Opaleye (*Girella nigricans*) and black croaker (*Cheilotrema saturnum*), both of which are often available on the local market, have been collected while mature and sexually active. Three species of bass (genus *Paralabrax*), all highly prized as sport fish, are numerous. Spiny lobster (*Panulirus interruptus*), of high commercial value, have been collected during the spawning cycle well inside the bay. Although the survey was conducted in a relatively short time, the data compiled should provide an adequate basis for the planning of future sampling or assessment programs concerning San Diego Bay.

Table 1. Location of Sampling Stations for Proximate Biological Survey.

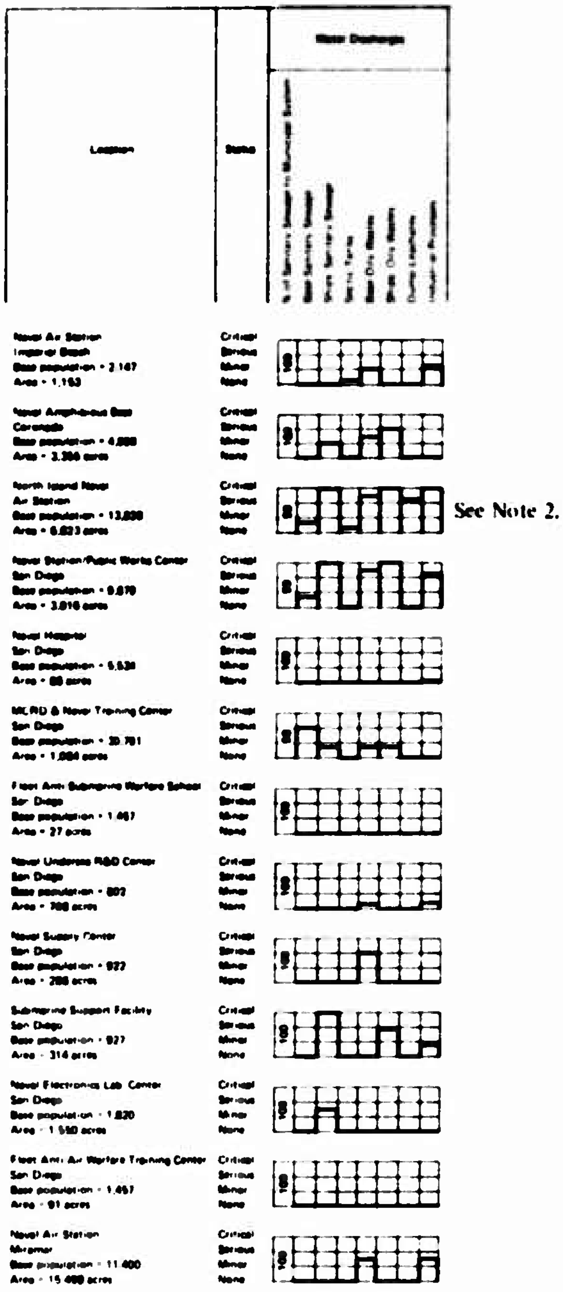
Station	Position	Description	Depth (ft)	Bottom
1	32°41'08"N 117°13'58"W	Seaward side of Ballast Point, below Navy degaussing station	7-10	Sand
2	32°42'16"N 117°14'04"W	NE side of NUC small boat docks, astern of *Sea-See* moor	10	Fine sand
3	32°43'19"N 117°13'10"W	NE side of commercial basin, at water end of ASW School underwater railroad catwalk	8-16	Coarse mud
4	32°43'37"N 117°10'44"W	Embarcadero open mooring area, junction of Coast Guard property and Harbor Drive	8-20	Fine sand and mud
5	32°42'31"N 117°11'23"W	North Island carrier basin, at base of old ferry bldg. walkway	5-8	Coarse mud with fine silt layer
6	32°41'36"N 117°08'53"W	Base of E end of Coronado Bridge, along Westgate property	5-18	Fine sand and mud
7	32°40'38"N 117°09'12"W	SE corner of Naval Amphibious Base	5-7	Fine hard packed sand
8	32°40'38"N 117°07'22"W	Naval Station, junction of Pier 6 and shoreline	18-24	Coarse mud
9	32°39'35"N 117°07'21"W	Head of Pier 13, Inactive Ship Facility	12-19	Fine mud
10	32°39'08"N 117°08'43"W	S side of entrance to Navy sailing club cove	5-7	Fine, hard packed sand

Table 2. Ship and Associated Population Data for Military Anchorages in San Diego Bay.

Location	Average Number of Ships/Day			Population On Board	Maximum Possible	
	1966 - 67*	1972	1973 (through July)		Number of Ships	Population on Board
Naval Station	52	47.5	53.5	7,040	120	18,000
Carrier Basin	2+	≃2	2	1,780	5+	6,700
Submarine Base	10+	≃10	10	1,010	24	2,800
Mooring buoys	5	<5	2	820	58	11,000
TOTAL	69+	≃64	67.5	10, 650	207	38,500

*Data for August 1966 to August 1967 compiled by Federal Water Pollution Control Administration, 1969

Table 3. Summary of Water Pollution Sources at Navy Installations in the San Diego Bay Area. (Source: Naval Civil Engineering Laboratory, 1972a.)



NOTES:

1. The status column gives an estimate of the seriousness of the discharge, based on volume and composition.

2. The discharge of industrial wastes from the Naval Air Station was eliminated in September 1973.

Table 4. Total Coliform Bacteria Concentrations of Surface Water Samples Taken during Proximate Survey.

Station	Coliform Bacteria per 100 ml	Time and Date Sample Collected (1973)
1	20	0910 23 April
	50	1200 1 May
	40	0838 15 May
2	40	0920 23 April
	40	1105 1 May
	1680	0919 15 May
3	30	0940 23 April
	60	1058 1 May
	540	0925 15 May
4	140	1015 23 April
	0	1040 1 May
	40	1012 15 May
5	30	1025 23 April
	30	1219 1 May
	40	1043 15 May
6	2000	1100 23 April
	130	1024 1 May
	260	1153 15 May
7	190	1120 23 April
	80	0820 1 May
	10	1109 15 May
8	530	1125 23 April
	10	1010 1 May
	100	1140 15 May
9	60	1130 23 April
	260	0845 1 May
	100	1126 15 May
10	30	1140 23 April
	100	0830 1 May
	0	1117 15 May

Table 5. Micromolluscan Content of Sediment Samples Taken during Proximate Survey.

Station	Species	Count
1	*Fartulum occidentale*	3
	Other Caecids*	3
	Mytilus edulis	1
	Tellina bodegensis	6
	Venerid*	1
	Vitrinella oldroydi	1
	Juvenile bivalves*	4
	Juvenile gastropods*	2
2	*Acteocina inculta*	1
	Chione sp.*	1
	Fartulum occidentale	1
	Mytilus edulis	1
	Tellina bodegensis	1
	Juvenile bivalves*	1
	Juvenile gastropods*	2
3	None	
4	*Caecum californicum*	1
5	None	
6	*Acteocina inculta*	2
7	*Barleeia* sp.*	1
	Caecum californicum	16
8	None	
9	None	
10	*Acteocina inculta*	2

* Unidentified.

Table 6. Species of Fish Collected During Proximate Survey, With Computed Weight-Length Constants.

Family and Species	Common Name	Weight-Length Constant $K = W/L^3$: K for grams/cm^3	Standard Deviation	K for lbs/in^3	Standard Deviation	Number Sampled
Triakidae						
Triakis semifasciata	leopard shark	3.7×10^{-3}	8.0×10^{-4}	1.4×10^{-4}	3.6×10^{-5}	25
Mustelus californicus	gray smoothhound	3.0×10^{-3}	8.0×10^{-4}	1.1×10^{-4}	2.9×10^{-5}	44
Mustelus lunulatus	sicklefin smoothhound	2.7×10^{-3}	5.3×10^{-4}	9.9×10^{-5}	2.0×10^{-5}	6
Rhinobatidae						
Rhinobatus productus	Shovelnose guitarfish	-	-	-	-	-
Dasyatidae						
Urolophus halleri	round stingray	1.1×10^{-2}	3.2×10^{-3}	3.9×10^{-4}	1.2×10^{-4}	7
Engraulidae						
Anchoa compressa	deepbody anchovy	-	-	-	-	-
Belonidae						
Strongylura exilis	California needlefish	1.3×10^{-3}	2.4×10^{-4}	4.8×10^{-5}	9.0×10^{-6}	2
Sphyraenidae						
Sphyraena argentea	California barracuda	4.8×10^{-3}	1.4×10^{-3}	1.7×10^{-4}	5.2×10^{-5}	2
Atherinidae						
Atherinopsis californiensis	jacksmelt	-	-	-	-	-
Leuresthes tenuis	California grunion	-	-	-	-	-
Serranidae						
Paralabrax clathratus	kelp bass	1.5×10^{-2}	9.9×10^{-4}	5.3×10^{-4}	3.6×10^{-5}	14
Paralabrax maculatofasciatus	spotted bass	1.4×10^{-2}	3.4×10^{-3}	4.9×10^{-4}	1.2×10^{-4}	24
Paralabrax nebulifer	sand bass	1.3×10^{-2}	2.7×10^{-3}	4.9×10^{-4}	9.8×10^{-5}	12
Haemulidae						
Anisotremus davidsonii	sargo	-	-	-	-	-

Table 6. Continued.

Family and Species	Common Name	Weight-Length Constant $K = W/L^3$				
		K for grams/cm^3	Standard Deviation	K for lbs/in^3	Standard Deviation	Number Sampled
Sciaenidae						
Cheilotrema saturum	Black croaker	1.5×10^{-2}	2.4×10^{-3}	5.4×10^{-4}	8.6×10^{-5}	47
Cynoscion nobilis	white seabass	-	-	-	-	-
Genyonemus lineatus	white croaker	1.4×10^{-2}	2.8×10^{-3}	5.1×10^{-4}	1.0×10^{-4}	2
Menticirrhus undulatus	California corbina	1.1×10^{-2}	1.8×10^{-3}	3.9×10^{-4}	6.4×10^{-5}	36
Roncador stearnsii	spotfin croaker	1.4×10^{-2}	9.3×10^{-4}	5.1×10^{-4}	3.4×10^{-5}	2
Seriphus politus	queenfish	-	-	-	-	-
Umbrina roncador	yellowfin croaker	1.5×10^{-2}	5.0×10^{-3}	5.1×10^{-4}	1.9×10^{-4}	8
Kyphosidae						
Hermosilla azurea	zebra perch	-	-	-	-	-
Girellidae						
Girella nigricans	opaleye	2.2×10^{-2}	1.5×10^{-3}	7.9×10^{-4}	5.4×10^{-5}	15
Scorpididae						
Medialuna californiensis	halfmoon	-	-	-	-	-
Embiotocidae						
Cymatogaster aggregata	shiner surfperch	-	-	-	-	-
Embiotoca jacksoni	black surfperch	2.0×10^{-2}	5.0×10^{-3}	7.2×10^{-4}	1.8×10^{-4}	7
Hyperprosopon argenteum	walleye surfperch	2.2×10^{-2}	3.2×10^{-3}	7.9×10^{-4}	1.2×10^{-4}	5
Phanerodon furcatus	white surfperch	1.7×10^{-2}	4.3×10^{-3}	5.9×10^{-4}	1.5×10^{-4}	11
Rhacochilus toxotes	rubberlip surfperch	2.2×10^{-2}	7.0×10^{-4}	7.9×10^{-4}	2.5×10^{-5}	4
Rhacochilus vacca	pile surfperch	-	-	-	-	-
Carangidae						
Trachurus symmetricus	jack mackerel	-	-	-	-	-
Scombridae						
Sarda chiliensis	Pacific bonito	1.1×10^{-2}	1.6×10^{-3}	3.8×10^{-4}	5.8×10^{-5}	50

Table 6. Continued.

Family and Species	Common Name	Weight-Length Constant $K = W/L^3$				Number Sampled
		K for grams/cm^3	Standard Deviation	K for lbs/in^3	Standard Deviation	
Stromateidae						
Peprilus semillimus	Pacific butterfish	2.2×10^{-2}	2.5×10^{-3}	8.1×10^{-4}	9.0×10^{-5}	7
Scorpaenidae						
Scorpaena guttata	sculpin	-	-	-	-	-
Cottidae						
Scorpaenichthys marmoratus	cabezon	5.4×10^{-4}(a)	-	-	-	-
Bothidae						
Paralichthys californicus	California halibut	9.4×10^{-3}	2.4×10^{-3}	3.4×10^{-4}	8.8×10^{-5}	8
Pleuronectidae						
Hypsopsetta guttulata	diamond turbot	1.4×10^{-2}	1.7×10^{-3}	5.1×10^{-4}	6.0×10^{-5}	4
Batrachoididae						
Porichthys myriaster	specklefin midshipman	1.1×10^{-2}	1.4×10^{-3}	4.1×10^{-4}	5.2×10^{-5}	30

(a) O'Connell, 1953.

Table 7. Species of Fish Collected during Proximate Survey by Station and Method of Collection (T = trap, G = gill net).

Family and Species	Station Number 1	2	3	4	5	6	7	8	9	10	Total
Triakidae											
Triakis semifasciata				G 4	G 5	G 5		G 2	G 20	G 1	37
Mustelus californicus		G 2		G 16		G 13	G 3	G 5	G 36	G 4	79
Mustelus lunulatus				G 4		G 16			G 9	G 3	32
Rhinobatidae											
Rhinobatus productus										G 2	2
Dasyatidae											
Urolophus halleri		G 1 T 1	G 2	G 3			T 6		G 3 T 2		18
Engraulidae											
Anchoa compressa				G 1							1
Belonidae											
Strongylura exilis					G 1					G 1	2
Sphyraenidae											
Sphyraena argentea		G 1			G 1						2
Atherinidae											
Atherinopsis californiensis				1[a]							1
Leuresthes tenuis					1[b]						1

[a] Ingested by halibut.

[b] Ingested by bonito.

Table 7. Continued.

Fish Collected

Family and Species	Station Number 1	2	3	4	5	6	7	8	9	10	Total
Serranidae											
Paralabrax clathratus	G 16			G 1	G 1						36
	T 11	T 6							T 1		
Paralabrax maculatofasciatus		G 8	G 5	G 1	G 1	G 2	G 2	G 1	G 3	G 6	127
	T 2	T 4	T 1		T 32	T 5	T 12	T 2	T 32	T 8	
Paralabrax nebulifer	G 1		G 1		G 4			G 4	G 1		69
		T 4	T 2		T 12		T 6	T 8	T 19	T 7	
Haemulidae											
Anisotremus davidsonii	G 1										1
Sciaenidae											
Cheilotrema saturnum	G 2	G 4	G 17	G 3	G 2	G 5	G 5	G 11	G308	G 27	1321
	T 1		T 3	T 7	T 5	T 11	T 64	T246	T370	T230	
Cynoscion nobilis	G 3									G 2	6
										T 1	
Genyonemus lineatus			G 1	G 1							2
Menticirrhus undulatus	G 19	G 12		G 2			G 1		G 1	G 11	46
Roncador stearnsii	G 1			G 1							2
Seriphus politus		G 1	G 1	G 1					G 1		4
Umbrina roncador	G 6	G 2									8
Kyphosidae											
Hermosilla azurea	G 3										3
Girellidae											
Girella nigricans	G 14	G 4	G 11		G 1						68
	T 2	T 15	T 2		T 11		T 3	T 5			

Table 7. Continued.

Fish Collected

Family and Species	Station Number 1	2	3	4	5	6	7	8	9	10	Total
Scorpididae											
Medialuna californiensis	G 1										1
Embiotocidae											
Cymatogaster aggregata						T 5				T 1	6
Embiotoca jacksoni	G 5	G 2	G 1								63
	T 19	T 33	T 3								
Hyperprosopon argenteum	G 20	G 30									50
Phanerodon furcatus	G 3	G 5	G 1	G 10					G 1		20
Rhacochilus toxotes	T 6	T 7									13
Rhacochilus vacca	G 5	G 2									13
	T 2	T 4									
Carangidae											
Trachurus symmetricus									G 1		1
Scombridae											
Sarda chiliensis	G 15	G 6	G 1	G 41	G 33	G 97	G 1	G 46	G136	G 21	397
Stromateidae											
Peprilus simillimus				G 4					G 3		7
Scorpaenidae											
Scorpaena guttata	T 1	T 1									2
Cottidae											
Scorpaenichthys marmoratus	G 1										1

Table 7. Continued.

Fish Collected

Family and Species	Station Number 1	2	3	4	5	6	7	8	9	10	Total
Bothidae											
Paralichthys californicus			G 3	G 3	G 1	G 1				G 1	9
Pleuronectidae											
Hypsopsetta guttulata		G 1	G 1	G 2	G 1						14
					T 1		T 6		T 2		
Batrachoididae											
Porichthys myriaster	G 1		G 3	G 19	G 3		G 1	G 1	G 4	G 4	38
									T 2		
Total Number of Species	21	18	14	19	13	8	10	8	16	14	
Total Number of Individuals	161	150	65	125	116	160	110	331	955	330	

Table 8. Length and Weight of Fishes Collected during Proximate Survey.

Family and Species	Number Collected	Length		Weight	
		Centimeters	Inches	Grams	Pounds
Triakidae					
Triakis semifasciata	37	46.6-138.0 m= 81.8	18.3-54.3 m=32.2	300-10750 m= 2545	0.66-23.7 m= 5.6
Mustelus californicus	79	46.1- 86.0 m= 65.7	18.1-33.9 m=25.9	310- 2000 m= 821	0.68- 4.4 m= 1.8
Mustelus lunulatus	32	59.4- 93.6 m= 67.3	23.4-36.9 m=26.5	577- 2608 m= 830	1.3 - 5.7 m= 1.8
Rhinobatidae					
Rhinobatus productus	2	Est. 76.2	Est. 30		
Dasyatidae					
Urolophus halleri	18	13.9- 35.6 m= 26.1	5.5-14.0 m=10.3	29- 454 m= 211	0.06- 0.99 m= 0.46
Engraulidae					
Anchoa compressa	1	14.0	5.5		
Belonidae					
Strongylura exilis	2	66.5, 67.3	26.2,26.5	340, 453	0.75, 0.99
Sphyraenidae					
Sphyraena argentea	2	44.2, 49.5	17.4,19.5	500, 454	1.1 , 0.99
Atherinidae					
Atherinopsis californiensis	1	Ingested by California halibut			

Table 8. Continued. Length and Weight of Fishes Collected

Family and Species	Number Collected	Length		Weight	
		Centimeters	Inches	Grams	Pounds
Leuresthes tenuis	1	Ingested by Pacific bonito			
Serranidae					
Paralabrax clathratus	36	22.7- 55.8 m= 31.4	8.9-21.9 m=12.4	225- 2567 m= 458	0.50- 5.6 m= 1.0
Paralabrax maculatofasciatus	127	18.1- 41.7 m= 28.4	7.1-16.4 m=11.1	81- 989 m= 316	0.18- 2.2 m= 0.69
Paralabrax nebulifer	69	17.5- 45.5 m= 28.9	6.9-17.9 m=11.4	72- 1500 m= 328	0.16- 3.3 m= 0.72
Haemulidae					
Anisotremus davidsonii	1	33.5	13.2	810	1.8
Sciaenidae					
Cheilotrema saturnum	1321	11.3- 37.2 m= 24.8	4.4-14.6 m= 9.8	21- 780 m= 231	0.05- 1.7 m= 0.51
Cynoscion nobilis	6	28.2- 42.7 m= 36.3	11.1-16.8 m=14.3		
Genyonemus lineatus	2	26.9, 27.8	10.6,10.9	240, 350	0.53, 0.77
Menticirrhus undulatus	46	33.0- 55.2 m= 39.7	12.9-21.7 m=15.6	454- 2272 m= 680	0.99- 4.9 m= 1.5
Roncador stearnsii	2	23.7, 48.4	9.3,19.1	175, 1700	0.39, 3.7
Seriphus politus	4	16.3- 27.3 m= 21.3	6.4-10.7 m= 8.4	81- 113 m= 98	0.18- 0.25 m= 0.22

Table 8. Continued. Length and Weight of Fishes Collected

Family and Species	Number Collected	Length		Weight	
		Centimeters	Inches	Grams	Pounds
Umbrina roncador	8	26.2- 30.3 m= 27.9	10.3-11.9 m=10.9	168- 385 m= 313	0.37- 0.85 m= 0.69
Kyphosidae					
Hermosilla azurea	3	31.9- 36.4 m= 33.5	12.6-14.3 m=13.2	680- 1133 m= 869	1.5- 2.5 m= 1.9
Girellidae					
Girella nigricans	68	19.8- 41.3 m= 24.6	7.8-16.3 m= 9.7	190- 1440 m= 371	0.42- 3.2 m= 0.82
Scorpididae					
Medialuna californiensis	1	25.7	10.1	226	0.5
Embiotocidae					
Cymatogaster aggregata	6	11.0- 11.6 m= 11.3	4.3- 4.6 m= 4.4		
Embiotoca jacksoni	63	15.3- 27.4 m= 21.1	6.0-10.8 m= 8.3	72- 475 m= 190	0.16- 1.0 m= 0.42
Hyperprosopon argenteum	50	15.2- 18.8 m= 17.1	5.9- 7.4 m= 6.7	91- 130 m= 113	0.20- 0.29 m= 0.25
Phanerodon furcatus	20	19.4- 26.5 m= 21.9	7.6-10.4 m= 8.6	140- 226 m= 167	0.31- 0.50 m= 0.37
Rhacochilus toxotes	13	26.9- 34.6 m= 32.2	10.6-13.6 m=12.7	428- 900 m= 734	0.94- 1.9 m= 1.6
Rhacochilus vacca	13	20.4- 33.3 m= 25.5	8.0-13.1 m=10.0		

Table 8. Continued.

Length and Weight of Fishes Collected

Family and Species	Number Collected	Length		Weight	
		Centimeters	Inches	Grams	Pounds
Carangidae					
Trachurus symmetricus	1	25.3	9.9	175	0.39
Scombridae					
Sarda chiliensis	397	33.4- 44.5 m= 38.4	13.1-17.5 m=15.1	396- 939 m= 621	0.87- 2.1 m= 1.4
Stromateidae					
Peprilus simillimus	7	15.4- 18.5 m= 17.0	6.1- 7.3 m= 6.7	85- 125 m= 110	0.19- 0.28 m= 0.24
Scorpaenidae					
Scorpaena guttata	2	19.3, 22.2	7.6, 8.7		
Cottidae					
Scorpaenichthys marmoratus	1	25.7	10.1	275	0.61
Bothidae					
Paralichthys californicus	9	26.2- 36.7 m= 30.1	10.3-14.4 m=11.9	181- 550 m= 267	0.40- 1.2 m= 0.60
Pleuronectidae					
Hypsopsetta guttulata	14	20.0- 27.5 m= 24.0	7.9-10.8 m= 9.4	90- 281 m= 186	0.20- 0.62 m= 0.41
Batrachoididae					
Porichthys myriaster	38	27.0- 41.3 m= 34.7	10.6-16.3 m=13.7	210- 750 m= 493	0.46- 1.7 m= 1.1

Table 9. Species of Fish Most Often Collected during Proximate Survey, Presented as a Percentage of the Total of the Species Taken at Specified Stations.

Species	Percentage of Total Catch of Species	Collected at Stations
Paralabrax clathratus	75	1
Hyperprosopon argenteum	100	1, 2
Menticirrhus undulatus	70	1, 2
Embiotoca jacksoni	100	1, 2, 3
Girella nigricans	70	1, 2, 3
Phanerodon furcatus	95	1, 2, 3, 4
Sarda chiliensis	95	4, 5, 6, 8, 9, 10
Paralabrax maculatofasciatus	75	5, 7, 9, 10
Paralabrax nebulifer	70	5, 8, 9
Sharks (3 species)	67	6, 8, 9
Cheilotrema saturnum	90	8, 9, 10
Menticirrhus undulatus	22	10

Table 10. Heavy Metal Content of Selected Marine Organisms from the San Diego Area.
(Source: California Regional Water Quality Control Board, San Diego Region, unpublished data.)

Species	Size/Sex	Collection Site	Date	Metal Content (parts per million, wet weight)							
				As	Cd	Cu	Cr	Pb	Hg	Ni	Zn
Hinnites multirugosus (rock scallop)	*	San Diego Bay	6/27/72	< 0.20	1.5	3.6	< 1.0	5.0	0.08	3.5	21
	*	San Diego Bay	6/27/72	< 0.20	2.3	3.4	< 0.7	3.7	0.06	3.3	18
	*	San Diego Bay	6/27/72	< 0.20	3.0	2.8	< 1.0	5.4	0.08	3.2	44
Panulirus interruptus (California spiny lobster)	8 lb/male	North San Diego Bay	10/12/71						0.32		
	7 lb/male	North San Diego Bay	12/20/71						0.78		
	7 lb/female	North San Diego Bay	2/20/72						0.69		
	2 lb/male	North San Diego Bay	3/19/72						1.70		
	6 lb/male	North San Diego Bay	3/19/72						0.50		
	11 lb/male	North San Diego Bay	3/19/72						0.77		
	sublegal	Off Point Loma	1973						0.18		
	sublegal	Off Point Loma	1973						0.19		
	sublegal	Off Point Loma	1973						0.26		
	sublegal	Off Point Loma	1973						0.27		
	sublegal	Off Point Loma	1973						0.40		
	sublegal	Off Point Loma	1973						0.43		
	sublegal	Off Point Loma	1973						0.31		
	sublegal	Off Point Loma	1973						0.71		
	sublegal	Off Point Loma	1973						1.10		
	*	San Clemente Island (SCI), Cortes Bank	1973						1.0		
	*	SCI, Cortes Bank	1973						1.8		
	*	SCI, Cortes Bank	1973						1.9		
	*	SCI, Cortes Bank	1973						2.4		
	*	SCI, Cortes Bank	1973						2.4		

Table 10. Continued.

Metal Content of Marine Organisms

Species	Size/Sex	Collection Site	Date	Metal Content (parts per million, wet weight)							
				As	Ca	Cu	Cr	Pb	Hg	Ni	Zn
Paralabrax clathratus (kelp bass)	12 in/female	San Diego Bay	6/9/72	< 0.05	< 1.0	1.0	< 0.8	16	0.11	4.8	11
	11 in/female	San Diego Bay	6/9/72	< 0.05	< 1.0	0.96	< 0.8	14	0.07	5.3	12
Paralabrax maculatofasciatus (spotted bass)	12.5 in/female	San Diego Bay	6/9/72	< 0.05	< 1.0	1.0	< 0.8	12	0.37	4.0	11
	12 in/male	San Diego Bay	6/9/72	< 0.05	< 1.0	1.0	< 0.8	12	0.22	3.8	14
Paralabrax nebulifer (sand bass)	15 in/male	San Diego Bay	6/9/72	0.13	< 1.0	0.87	< 0.8	17	0.23	2.9	9.3
	14 in/male	San Diego Bay	6/9/72	< 0.05	< 1.0	0.74	< 0.8	11	0.16	2.3	8

NOTES:

1. An asterisk indicates that data were not available.
2. Sublegal means measuring less than 3.25 inches from rear edge of eye socket to rear edge of body shell.

Table 11. Checklist of Plants and Marine Animals Known to Inhabit the San Diego Bay Area (Sources: Eigenmann, 1892; Parrish and Mackenthun, 1968; Ford *et al.*, 1970; U. S. Army Corps of Engineers, 1973; Proximate Survey).

A. Algae and Salt Marsh Plants

Amblyapappus pusillus (coast weed)
Antithamnion sp. (red algae)
Artemisia californica (California sagebrush)
Atriplex canescens (salt bush)
A. lindleyi (salt bush)
A. semibaccata (Australian salt bush)
A. (nr) truncata (salt bush)
A. watsonii (Watson salt bush)
Baccharis sarothroides (chaparral broom)
B. viminea (mule fat)
Bassia hyssopifolia (bassia)
Batis maritimun (saltwart)
Bromus rubens (red brome)
Cardionema ramossisima (tread lightly)
Centaurea melitensis (star thistle)
Ceramium eatonian (red algae)
C. spp. (red algae)
Chaetomorpha sp. (green algae)
Chrysanthemum (nr) carinatum (tricolar chrysanthemum)
Cladophora sp. (green algae)
Colpomenia sinusa (brown algae)
Cotula coronopifolia (brass buttons)
Cressa truxillensis (alkali weed)
Cuscuta salina (salt marsh dodder)
Dasya pacifica (red algae)
Derbesia marina (green algae)
Distichlis spicata (salt grass)
Ectocarpus spp. (brown algae)
Egregia laevigata (brown algae)
Enteromorpha spp. (filamentous green algae)
Eriogonum fasciculatum (coastal buckwheat)
Foeniculum vulgare (sweet fennel)
Frankenia palmeri (yerba reuma)
F. grandifolia (alkali health)
Gigartina spp. (red algae)
Gracilaria verrucosa (red algae)
Griffithsia sp. (red algae)
Haplopappus venetus (golden bush)
Hardeum murinum (sterile barley)
Heliotropium curassavicum (Chinese parsley)
Heterotheca grandiflora (telegraph weed)
Honanthochloe littoralis (salt cedar)
Hutchinsia procumbens
Hypnea valentiae (red algae)
Jaumea carnosa (jaumea)
Juncus acutis (spiny rush)
Limonium californicum (sea lavender)
Lobularia maritima (sweet allypsum)
Lotus nuttallianus (beach lotus)
Mesembryanthemum chilense (sea fig)
M. crystallinum (ice plant)
M. nodiflorum (little ice plant)
Nemocaulis denudata (thread stem)
Nicotiana glauca (tree tobacco)
Oenothera cheiranthifolia (beach evening primrose)
Parafolis incurva (sickle grass)
Pluchea sericea (arrow weed)
Polygonum aviculare (common knot weed)
Polypogon monspeliensis (rabbit foot grass)
Polysiphonia pacifica (red algae)
Rhizoclonium sp. (green algae)
Rhodymenia spp. (red algae)
Rumex crispus (curley dock)
Ruppia maritima (ditch grass)
Salicornia bigelovii (animal pickleweed)
S. europea (saltflat annual pickleweed)
S. subterminalis (glasswart)
S. virginica (pickleweed)
Salix lasiolepis (arroyo willow)
Salsola kali (Russian thistle)
Salvia mellifera (black sage)
Saueda torreyana (torry seablite)
S. californica (California seablite)
Sargassum muticum (brown algae)
S. agarhianum (brown algae)
Schinus molle (California pepper tree)
Spartina foliosa (cordgrass)
Spergularia marina (salt marsh sand spurry)
Tamarix sp. (tamarisk)
Tillaea erecta (pigmy weed)
Triglochin maritima (arrow grass)
Typha latifolia (common cattail)
Ulothrix sp. (green algae)
Ulva latissima (sea lettuce)
Yucca schidigera (Mohave yucca)
Zostera marina (eelgrass)

B. Marine Invertebrates

Porifera
Tetilla mutabilis (wandering sponge)

Coelenterates
Aglaophenia sp. (ostrich plume hydroid)
Cerianthus (nr) aestuari (burrowing anemone)
Corymorpha palma (white hydroid)
Edwardsiella californica (burrowing anemone)
Epiactis prolifera (anemone)
Obelia sp. (hydroid)
Tubularia sp. (naked hydroid)

Bryozoans
Bugula neritina (bryozoan)
Zoobotryon verticillatum (bryozoan)

Echinoderms
Ophiuroids
Amphiodia (nr) occidentalis (brittle star)
Holothuroids
Leptosynapata albicans (Southern California sea cucumber)

Table 11. Continued. Inhabitants of San Diego Bay Area

B. Marine Invertebrates (cont.)

Annelids

Armandia bioculata (polychaete)
Capitata ambiseta (polychaete)
Glycera americana (polychaete)
Haploscolopos elongatus (polychaete)
Lumbrineris californiensis (polychaete)
L. zonata (polychaete)
Megalomma sp. (polychaete)
Neanthes caudata (polychaete)
Polydora sp. (polychaete)

Molluscs

Pelecypods

Adula diegensis (San Diego peapod)
Chione californiensis (banded cockle)
C. fluctifraga (smooth cockle)
C. undatella (wavy cockle)
Chionista sp.
Cyclocardia sp. (cardita)
Diplodonta sp. (diplodon)
Laevicardium substriatum (eggshell clam)
Leptopecten sp. (scallop)
Lyonsia californica (California lyonsia)
Macoma nasuta (bent-nosed clam)
Mactra californica (California dish clam)
Modiolus demissus (ribbed mussel)
Mytilus edulis (bay mussel)
Protothaca staminea (common littleneck)
Solen rosaceus (rosy razor clam)
Tagelus californianus (jackknife clam)
T. subteres (jackknife clam)
Tapes semidecussata (Japanese littleneck)
Tellina bodegensis (tellin)
Tivela sp. (venus clam)
Schizothaerus nuttalli (gaper)

Gastropods

Acteocina mazdalenensis (glassy bubble)
A. inculta (bubble shell)
Barleeia sp.
Bulla gouldiana (Gould's bubble)
Caecum californicum (California caecum)
Cerithidea californica (California horn shell)
Crepidula onyx (onyx slipper shell)
Crucibulum spinosum (cup and saucer limpet)
Fartulum occidentale (caecid)
Haminaea vesicula (blister paper bubble)
Lacuna marmorata (chink shell)
Mitrella carinata (dove shell)
Nassarius tegulus (mud-dog whelk)
Odostomia sp. (odostome)
Olivella sp. (olive shell)
Ophiodermella ophioderma (penciled turret shell)
Tachyrhynchus sp. (turret shell)
Vitrinella oldroydi (vitrinella)
Vitrinorbis diegensis (vitrinorbis)

Crustaceans

Amphipods

Ericthonius brasiliensis (corophid amphipod)

Isopods

Cilicaea sculpta (sphaeromid isopod)
Seriolis carinata (isopod)

Decapods

Cancer antennarius (common rock crab)
C. anthonyi (rock crab)
Hemigrapsus oregonensis (mudflat crab)
Hippolyte californiensis (grass shrimp)
Lophopanopeus sp. (xanthid crab)
Panulirus interruptus (California spiny lobster)
Processa canaliculata (crangonid shrimp)
Pugettia producta (kelp crab)
Pyromaia tuberculata (spider crab)
Speocarcinus californiensis (mudflat crab)
Spirontocaris sp. (shrimp)

Stomatopods

Pseudosquilla sp. (mantis shrimp)
Squilla polita (mantis shrimp)

Cirripeds

Balanus amphitrite (acorn barnacle)
Chthamalus sp. (barnacle)

Tunicates

Botryllus sp. (tunicate)
Ciona intestinalis (tunicate)
Styela barnharti (tunicate)
S. plicata (tunicate)

C. Vertebrates

Sharks and Rays

Heterodontidae

Heterodontus francisci (horn shark)

Triakidae

Triakis semifasciata (leopard shark)
Rhinotriacis henlei (brown smoothhound)
Mustelus californicus (gray smoothhound)
M. lunulatus (sicklefin smoothhound)

Carcharhinidae

Galeorhinus zyopterus (soupfin shark)
Prionace glauca (blue shark)

Sphyrnidae

Sphyrna zygaena (hammerhead shark)

Squalidae

Squalus acanthias (dogfish)

Squatidae

Squatina squatina (angel shark)

Rhinobatidae

Rhinobatus productus (shovelnose guitarfish)
R. exasperatus (guitarfish)
R. triseriatus (guitarfish)

Dasyatidae

Urolophus halleri (round stingray)

Teleost Fishes

Engraulidae

Anchoa compressa (deepbody anchovy)
A. delicatissima (slough anchovy)

Belonidae

Strongylura exilis (California needlefish)

C. Vertebrates (cont.)
- Cyprinodontidae
  - *Fundulus parvipinnis* (killifish)
- Hemiramphidae
  - *Hyporhamphus rosae* (California halfbeak)
- Syngnathidae
  - *Syngnathus auliscus* (barred pipefish)
  - *S. griseolineatus* (bay pipefish)
- Sphyraenidae
  - *Sphyraena argentea* (California barracuda)
- Mugilidae
  - *Mugil cephalus* (mullet)
- Atherinidae
  - *Atherinops affinis* (topsmelt)
  - *Atherinopsis californiensis* (jacksmelt)
  - *Leuresthes tenuis* (grunion)
- Serranidae
  - *Paralabrax clathratus* (kelp bass)
  - *P. maculatofasciatus* (spotted bass)
  - *P. nebulifer* (sand bass)
- Haemulidae
  - *Anisotremus davidsonii* (sargo)
- Sciaenidae
  - *Cheilotrema saturnum* (black croaker)
  - *Cynoscion nobilis* (white seabass)
  - *Genyonemus lineatus* (white croaker)
  - *Menticirrhus undulatus* (California corbina)
  - *Roncador stearnsii* (spotted croaker)
  - *Seriphus politus* (queenfish)
  - *Umbrina roncador* (yellowfin croaker)
- Kyphosidae
  - *Hermosilla azurea* (zebraperch)
- Girellidae
  - *Girella nigricans* (opaleye)
- Scorpididae
  - *Medialuna californiensis* (halfmoon)
- Embiotocidae
  - *Cymatogaster aggregata* (shiner surfperch)
  - *Embiotoca jacksoni* (black surfperch)
  - *Hyperprosopon argenteum* (walleye surfperch)
  - *Phanerodon furcatus* (white surfperch)
  - *Rhacochilus toxotes* (rubberlip surfperch)
  - *R. vacca* (pile surfperch)
- Carangidae
  - *Trachurus symmetricus* (jack mackerel)
- Scombridae
  - *Sarda chiliensis* (Pacific bonito)
- Stomateidae
  - *Peprilus semillimus* (Pacific butterfish)
- Blenniidae
  - *Hypoblennius gentilis* (bay blenny)
- Gobiidae
  - *Clevelandia ios* (arrow goby)
  - *Gillichthys mirabilis* (longjaw mudsucker)
  - *Ilypnus gilberti* (cheekspot goby)
  - *Quietula y-cauda* (shadow goby)
- Clinidae
  - *Heterostichus rostratus* (giant kelpfish)
- Scorpaenidae
  - *Scorpaena guttata* (sculpin)
- Cottidae
  - *Leptocottus armatus* (staghorn sculpin)
  - *Scorpaenichthys marmoratus* (cabezon)
- Bothidae
  - *Paralichthys californicus* (California halibut)
  - *Xystreurys liolepis* (fantail sole)
- Pleuronectidae
  - *Hypsopsetta guttulata* (diamond turbot)
- Batrachoididae
  - *Porichthys myriaster* (specklefin midshipman)

Table 12. Checklist of Birds Inhabiting the San Diego Bay Area, with Notes on Abundance and Ecological Preferences. (Source: U. S. Army Corps of Engineers, 1973, with revisions.)

Gavia immer (common loon)	M, WR. Uncommon. Feeds largely on fish in shallow to moderate depths.
G. artica (Arctic loon)	M, WR. Uncommon in bay, abundant offshore. Feeding habits similar to common loon.
G. stellata (red-throated loon)	M, WR. Occurs annually in small numbers but only at mouth of bay; prefers open ocean.
Podiceps auritus (horned grebe)	M, WR. Occurs annually in small numbers. Feeds on fish and invertebrates in shallow waters.
P. caspicus (eared grebe)	M, WR. Abundant. Feeds on fish and invertebrates in shallow to moderately deep waters. Largely dependent on sheltered waters, though some feeding may be done offshore.
Aechmophorus occidentalis (western grebe)	M, WR. Abundant offshore where it feeds, but uncommon in bay.
Podilymbus podiceps (pied-billed grebe)	M, WR. Uncommon in bay but totally dependent on shallow water habitats, where it feeds on invertebrates. Prefers small ponds, creeks, marshes.
Pelecanus erythrorhynchos (white pelican)	M. Rare migrant and occasional winter resident, not occurring annually.
P. occidentalis (brown pelican)	R. Endangered. Feeds in north bay and in open sea; rests on sandbars in south bay.
Phalacrocorax auritus (double-crested cormorant)	R. Breeds locally, found in bay throughout year, particularly in winter. Feeds on fish in moderately deep water and restricted largely to channel areas and mouth of bay.
P. penicillatus (Brandt's cormorant)	R. Breeds locally, found in bay throughout year, particularly in winter. Feeds on fish in moderately deep water and restricted largely to channel areas and mouth of bay.
Ardea herodias (great blue heron)	Common to abundant all year, particularly in winter. Feeds on mudflats and in shallow water areas. Totally dependent on aquatic habitats. A few pairs may still breed in Point Loma area.

NOTE: M = migrant, R = resident, W = winter, S = summer.

Casmerodius albus (common egret)	M, WR. Totally dependent upon shallow water habitats. Occurs annually in small numbers, particularly at south end of bay.
Leucophoyx thula (snowy egret)	M, WR. Common to abundant in many areas of bay. Feeds largely on fish.
Bubulcus ibis (cattle egret)	M, WR. This bird, although exotic to the area, has been observed in the south bay. It resembles the common egret in its habits.
Branta nigricans (black brant)	M. Rare. Feeds on eel-grass in shallow, sheltered waters.
Dabbling Ducks *Anas platyrhynchos* (mallard) *A. strepera* (gadwall) *A. acuta* (pintail) *A. carolininensis* (green-winged teal) *A. crecca* (teal) *A. discors* (blue-winged teal) *A. cyanoptera* (cinnamon teal) *Mareca americana* (American widgeon) *Spatula clypeata* (shoveler)	M, WR. These "dabbling ducks" prefer fresh water habitats and are generally uncommon or rare on the bay. They appear to use the bay mainly as a refuge and do little feeding there. All may occur as migrants or winter residents.
Diving Ducks *Aythya americana* (redhead) *A. valisineria* (canvas-back) *A. marila* (greater scaup) *Clangula hyemalis* (oldsquaw)	M, WR. These "diving ducks" prefer shallow salt water habitats, but all are rare locally because San Diego is beyond their normal range.
Aythya affinis (lesser scaup)	M, WR. Common to abundant. Feeds in shallow water areas.
Bucephala clangula (common goldeneye)	M, WR. Very uncommon in San Diego area. Rarely visits bay.

NOTE: M = migrant, R = resident, W = winter, S = summer.

Bucephala albeola (bufflehead)	M, WR. Fairly common on bay. Dives for food in shallow to moderate depths.
Melanitta deglandi (white-winged scoter), *Oldemia nigra* (common scoter)	M, WR. Rare in San Diego area, which is beyond normal wintering range. Occasionally visits bay; feeds on bottom fauna.
Melanitta perspicillata (surf scoter)	M, WR. Most common waterfowl on bay. Feeds in bay and along beaches.
Oxyura jamaicensis (ruddy duck)	M, WR. Breeds in some local lagoons, though not in bay area. Fairly common but seems to prefer more sheltered waters, such as San Diego River flood control channel, lagoons, Mission Bay. Dives for food in shallow waters.
Mergus serrator (red-breasted merganser)	M, WR. Common fish-eating duck; can feed in shallow or deep water areas.
Falco peregrinus (peregrine falcon)	R. Endangered. Feeds in marshes, along cliffed shorelines, and in inland areas.
Rallus longirostris (clapper rail)	R and M. Endangered. Feeds in salt marshes and on mudflats.
Laterallus jamaicensis (black rail)	M. Rare. Feeds in salt marshes.
Fulica americana (coot)	M. Coots are not uncommon on the bay in winter and during migration. They feed in shallow water areas and often graze in parks. A few breed in marshes at the south end of the bay.
Himantopus mexicanus (black-necked stilt)	Breeds commonly at south end of bay in salt works. Feeds largely in salt ponds. Numbers increase in winter.
Recurvirostra americana (avocet)	M, WR. In fair numbers. Feeds in tidal creeks, shallow water areas, on small fish. May breed at south end of bay.
Charadrius semipalmatus (semipalmated plover)	M, WR. In fair numbers. Feeds on mudflats.
C. vociferus (killdeer)	R. A resident species, breeding in fill areas along bay. Numbers increase in winter. Prefers to feed in areas above tidal influence, though does occur on mudflats.
C. alexandrinus (snowy plover)	R. A resident species, breeding in small numbers along bay shore, particularly at salt works. Becoming rarer as undistrubed habitats decrease.

NOTE: M = migrant, R = resident, W = winter, S = summer.

Pluvialis dominica (golden plover)	M. Rare visitor to bay in migration; prefers upland habitats.
Squatarola squatarola (black-bellied plover)	W. Abundant in winter and during migration. The San Diego bay area is apparently a major wintering ground for this species. Feeds mainly on mudflats.
Limosa fedoa (marbled godwit)	W. Abundant in winter and during migration. Feeds on invertebrates on mudflats.
Numenius phaeopus (Hudsonian curlew, whimbrel)	Occasional in bay; prefers outer beaches.
N. americanus (long-billed curlew)	M, WR. Fairly common migrant and winter resident. Feeds on soft mudflats.
Totanus melanoleucus (greater yellowlegs), *T. flavipes* (lesser yellowlegs)	M, WR. Both species of yellowlegs are fairly common during migration, less so in winter. They require mudflats and shallow water (ponds, pools) for feeding.
Catoptrophorus semipalmatus (willet)	M, WR. Abundant on mudflats and also on sandy outer beaches.
Arenaria interpres (ruddy turnstone)	M, WR. Common, sometimes abundant migrant on mudflats, occasionally outer beaches.
A. melanocephala (black turnstone)	M, WR. Prefers rocky beaches, rarely straying to mudflats of the bay.
Limnodromus griseus (short-billed dowitcher), *L. scolopaceus* (long-billed dowitcher)	M, WR. These closely similar species are difficult to identify in the field. The short-billed dowitcher is common to abundant on the bay mudflats. Long-bills prefer pond habitats.
Calidris canutus (knot)	M, WR. Common on mudflats in migration.
Crocethia alba (sanderling)	M, WR. Common on mudflats but prefers outer beaches.
Ereunetes mauri (western sandpiper)	M, WR. Abundant migrant and winter resident. Requires mudflat areas. Some individuals return to San Diego area each year in migration.
Erolia alpina (dunlin)	M, WR. Abundant from late fall through early spring. One of the most common shorebirds in the area, found almost exclusively on mudflats.
E. minutilla (least sandpiper)	M, WR. Common on mudflats but more likely to be found at edge of marsh vegetation.

NOTE: M = migrant, R = resident, W = winter, S = summer.

Steganopus tricolor (Wilson's phalarope)	M. Common in migration, absent in winter. Prefers salt ponds.
Lobipes lobatus (northern phalarope)	M, WR. Virtually confined to salt ponds, where it is often in great abundance.
Phalaropus fulicarius (red phalarope)	M, WR. Status varies greatly from year to year. When present, it is found with above species in salt works.
Larus occidentalis, Larus spp. (western gull)	Nine species of gulls frequent the bay waters. Only one, the western gull, breeds locally; a few birds nest in sheltered areas of the bay; thousands nest on Los Coronados. The remaining species are migrants and/or winter residents, arriving in late October and departing in March.
	Thousands of gulls of several species (glaucous, winged, western, herring, California, Thayer's, ring-billed) winter in the San Diego area, attracted by the availability of food at refuse dumps. These species use the bay area largely for roosting, and few individuals feed there to any great extent. Heermann's and Bonaparte's gulls do remain in the bay and in-shore areas, where they feed on small fish. Mew gulls, also, are rarely found far from open water, and they often occur near sewer outfalls.
Sterna forsteri (Forster's tern)	SR. This tern is largely a summer resident of the bay, although some individuals do winter locally. It nests commonly on the salt works property and feeds to a large extent on small fishes within the bay.
S. hirundo (common tern)	M. Fairly common at times; feeds in bay and on open ocean.
S. albifrons (least tern)	SR. Endangered. Nests in south bay; feeds in sheltered bay waters.
Thalasseus maximus (royal tern)	M. Fairly common offshore but uncommon in bay area.
T. elegans (elegant tern)	SR. Rare. Nests in south bay; feeds in open sea.
Hydroprogne caspia (Caspian tern)	R. Breeds on salt works in south bay; many birds winter locally. Feeds on fresh water and bay fishes, less commonly offshore.

NOTE: M = migrant, R = resident, W = winter, S = summer.

Chlidonias niger (black tern)	Occasional migrant; prefers lagoons, ponds.
Passerculus sandwichensis (Savannah sparrow)	R. Common resident of salt marsh areas; numbers increase in winter with addition of migrant birds. Totally dependent upon this habitat.

NOTE: M = migrant, R = resident, W = winter, S = summer.

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APPENDIX A

Sources of Environmental Information for San Diego Bay

1. California Department of Fish and Game	
San Diego Office	(714) 236 7311
2. California Regional Water Quality Control Board	
San Diego Region	
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Joseph Barry, Environmental Specialist	Same
3. Lockheed Ocean Laboratory	
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Dr. Don Hunsaker and Robert Koningsar	(714) 233 9147
(Studies concerning hvdroid distributions within San Diego Bay)	
Dr. James Mathewson	(714) 286 5436
(Impact of pollutants, expecially lead and mercury, upon spiny lobsters, and trace metal loads of sediments in San Diego Bay)	
Dr. Harriet Schapiro	(714) 286 6767
(Diseases in spiny lobsters)	
6. San Diego Unified Port District	
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APPENDIX B

California and Federal Air-Quality Standards (Source: Naval Civil Engineering Laboratory, 1972b)

Pollutant	Averaging Time	Federal Standards Primary ppm	Federal Standards Primary $\mu g/m^3$	Federal Standards Secondary ppm	Federal Standards Secondary $\mu g/m^3$	State Standards ppm	State Standards $\mu g/m^3$
Photochemical oxidants	1 hr	0.08	160	0.08	160	0.1	200
Hydrocarbons	3 hr (6-9 AM)	0.24	160	0.24	160	0.24	160
Oxides of nitrogen (NO_x)	Annual	0.05	100	0.05	100	0.05	100
	24 hr	-	-	-	-	-	-
	1 hr	-	-	-	-	0.25	500
Carbon monoxide (CO)	24 hr	-	-	-	-	-	-
	12 hr	-	-	-	-	10	11000
	8 hr	9.0	10000	9.0	10000	9	10000
	1 hr	35.0	40000	35.0	40000	40	45000
Suspended particulate	Annual [a]	NA [b]	75	NA	60	NA	60
	24 hr	NA	260	NA	150	NA	150
Sulfur dioxide (SO_2/SO_x)	Annual	0.03	80	0.02	60	0.02	60
	24 hr	0.14	365	0.10	260	0.04	100
	3 hr	-	-	0.50	1300	0.50	1300
	1 hr	-	-	-	-	0.50	1300
Hydrogen sulfide	1 hr	-	-	-	-	0.03	42
Lead particulate	30 day	-	-	-	-	NA	1.5
Ethylene	8 hr	-	-	-	-	0.5	600
	1 hr	-	-	-	-	0.1	100

[a] Geometric mean. [b] Parts per million is not meaningful for solid particles.

NOTES:

1. $\mu g/m^3$ = micrograms per cubic meter = 41 x ppm x pollutant molecular weight; results rounded off to nearest 100 for state standards.

2. ppm = parts of pollutant per million parts of air at standard condition; values are for maximum concentrations, not to be exceeded more than once per year within the required averaging time, except for those standards based on annual averages.

APPENDIX C

Physical-Chemical Water and Sediment Quality Data for San Diego Bay

a) Sediment sample data collected by California Regional Water Quality Control Board, San Diego Region, during March-June 1972. The location of the sampling sites is shown in figure C-1; letters indicate replicate samples taken in the same location as the corresponding numbered sample. All concentrations are in parts per million. (Source: Joseph Barry, personal communication.)

Sample Site	Date (1972)	Arsenic	Mercury	Lead	Zinc	Nickel	Copper	Chromium
1	March 7	7.6	1.5	--	140	63	37	--
1A	March 7	1.1	2.4	--	140	60	130	--
2	March 7	3.9	1.9	--	300	62	150	--
2A	March 7	9.6	1.9	--	190	58	62	--
3	March 7	9.5	0.96	--	140	57	57	--
3A	March 7	2.9	5.9	--	310	66	170	--
4	March 7	8.4	1.1	--	37	35	9.8	--
4A	March 7	2.9	0.72	--	38	59	11	--
5	March 7	0.26	0.44	--	69	43	14	--
5A	March 7	1.1	0.76	--	41	30	11	--
6	March 7	1.2	2.1	--	93	67	29	--
6A	March 7	0.70	1.9	--	83	50	25	--
7	March 7	<0.10	1.1	--	83	50	25	--
7A	March 7	0.94	1.1	--	77	40	23	--
8	March 7	1.3	0.7	--	36	25	11	--
8A	March 7	<0.10	1.1	--	88	42	22	--
9	March 7	6.0	11.1	--	150	40	140	--
9A	March 7	10.0	8.5	--	140	42	130	--
10	March 7	13.0	4.8	--	100	53	70	--
10A	March 7	6.9	6.7	--	130	55	100	--
11	March 7	3;5	0.49	--	16	43	8.8	--

(a) Continued.

Sample Site	Date (1972)	Arsenic	Mercury	Lead	Zinc	Nickel	Copper	Chromium
12	June 2	3.0	0.60	--	170	20	56	38
12A	June 2	2.1	0.50	--	100	17	53	36
12B	June 2	1.0	0.34	--	63	13	0.28	28
12C	June 2	1.1	0.26	--	63	13	72	75
13	June 2	3.0	0.66	--	270	20	72	75
13A	June 2	2.1	0.42	--	190	17	45	51
13B	June 2	4.0	0.74	--	370	13	77	70
13C	June 2	1.9	0.38	--	83	13	33	34
14	June 2	4.0	2.2	--	210	17	100	35
14A	June 2	4.2	2.6	--	250	18	110	36
14B	June 2	5.8	2.5	--	620	28	280	66
14C	June 2	7.7	3.0	--	600	28	310	69
14D	June 2	6.8	2.4	--	580	25	250	77
14E	June 2	5.7	1.1	--	370	18	150	52
14F	June 2	3.5	2.5	--	320	29	110	49
14G	June 2	3.4	2.5	--	350	19	120	43
15	June 2	3.9	1.9	--	200	16	68	37
15A	June 2	7.8	2.1	--	200	19	81	51
15B	June 2	2.7	1.7	--	180	19	60	34
15C	June 2	8.4	1.6	--	190	21	98	40
15D	June 2	7.2	2.8	--	370	28	98	67
15E	June 2	6.5	2.7	--	420	29	98	59
15F	June 2	1.2	0.5	--	68	13	28	19
15G	June 2	1.2	0.8	--	63	11	23	18
16	June 8	2.1	0.48	36	91	19	59	41
16A	June 8	2.1	0.35	29	76	14	42	31
16B	June 8	2.2	0.35	21	51	10	30	22
16C	June 8	1.3	0.39	28	55	6	30	17
17	June 8	0.9	0.15	23	26	8	12	10
17A	June 8	0.4	0.17	25	32	8	12	10
17B	June 8	0.7	0.15	21	43	11	13	18
17C	June 8	0.6	0.12	19	35	11	9.6	12
18	June 8	0.2	0.09	20	22	8	9	8
18A	June 8	1.0	0.17	25	48	11	23	17
18B	June 8	0.4	0.17	24	44	12	20	17
18C	June 8	1.7	0.22	25	64	16	32	33

(a) Continued.

Sample Site	Date (1972)	Arsenic	Mercury	Lead	Zinc	Nickel	Copper	Chromium
19	June 8	0.4	0.14	25	37	9	14	12
19A	June 8	0.6	0.12	23	37	9	13	16
19B	June 8	1.0	0.2	24	62	14	18	22
19C	June 8	1.2	0.16	24	45	12	14	20
20	June 8	0.4	0.048	18	20	10	6	12
20A	June 8	0.2	0.030	18	11	8	3.5	10
20B	June 8	1.6	0.064	23	59	19	18	31
20C	June 8	0.5	0.11	25	65	19	29	35

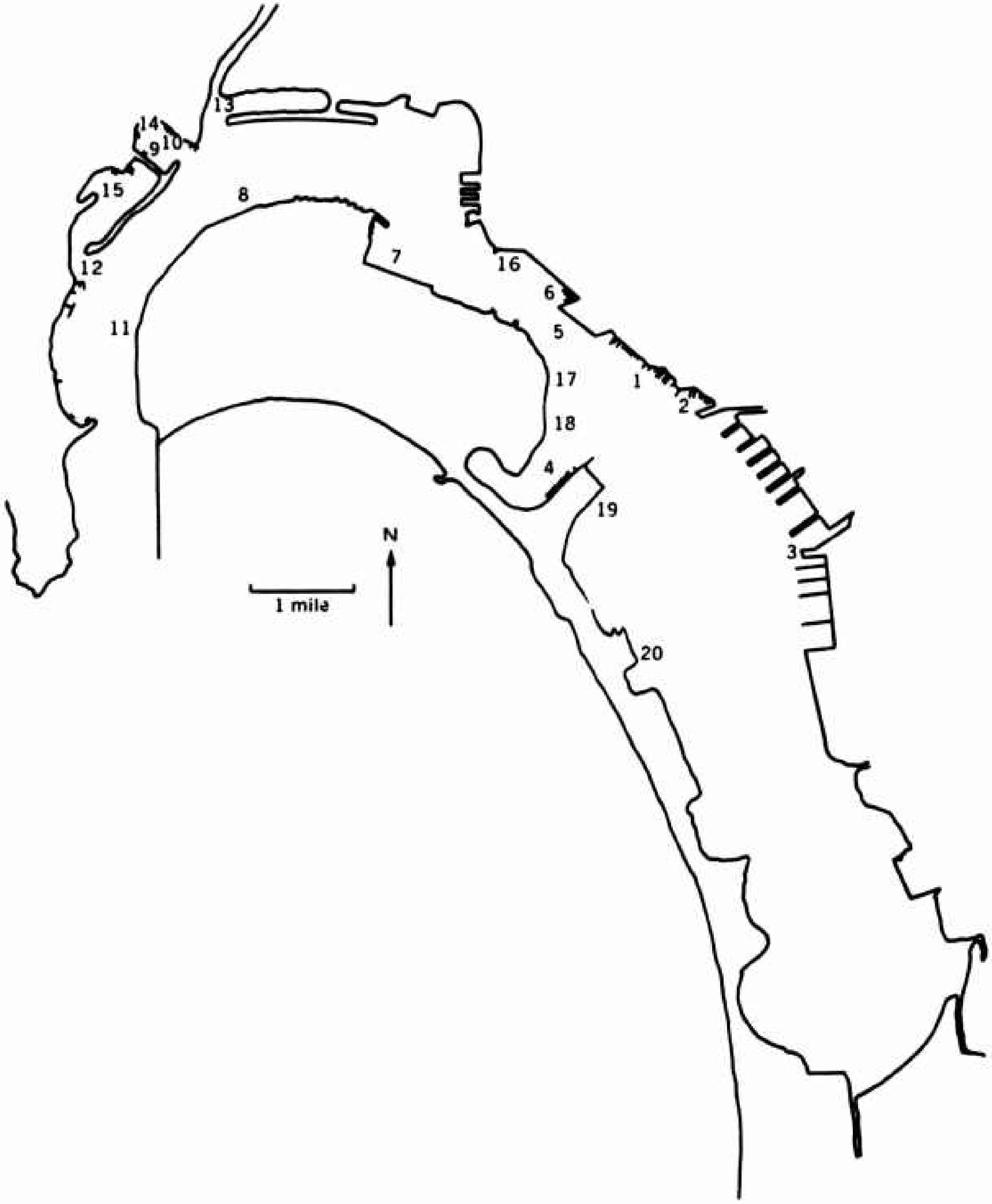

Figure C-1. Location of sediment sampling stations established in San Diego Bay by the California Regional Water Quality Control Board, San Diego Region, March-June 1972. (Replicate samples at the same site are indicated by a single site number on this map.)

b) Water sample analysis data collected by Lockheed Ocean Laboratory from the fall of 1970 to the summer of 1971. The sampling stations are shown in figure C-2. Parameter data represent the mean value compiled for each station over the entire sampling period. (Source: P. H. Benson, personal communication.)

Parameter	Unit	Station Number 1	2	3	4	5	6
Temperature	°C	18.3	19.6	17.99	18.1	20.1	19.86
Salinity	0/00	32.06	31.35	32.79	33.52	32.95	31.96
Dissolved O_2	ppm	5.3	4.8	5.4	5.4	4.6	4.5
pH		7.97	7.9	7.9	7.9	7.8	7.9
Copper	μg/l	3.5	2.6	2.9	2.7	3.0	3.2
Mercury	μg/l	15.0	15.0	15.0	15.0	15.0	15.0
Lead	μg/l	17.0	< 30.0	17.7	20.6	19.9	19.6
Zinc	μg/l	35.96	39.2	33.8	41.98	35.3	42.1
Phosphate	μgP/l	49.19	116.63	24.85	27.94	45.19	82.73
Nitrite	μgN/l	2.17	2.88	2.22	2.54	3.63	4.47
Nitrate	μgN/l	37.3	77.28	35.86	38.72	35.10	42.2
Ammonia	μgN/l	35.17	46.76	31.38	20.82	47.77	46.13

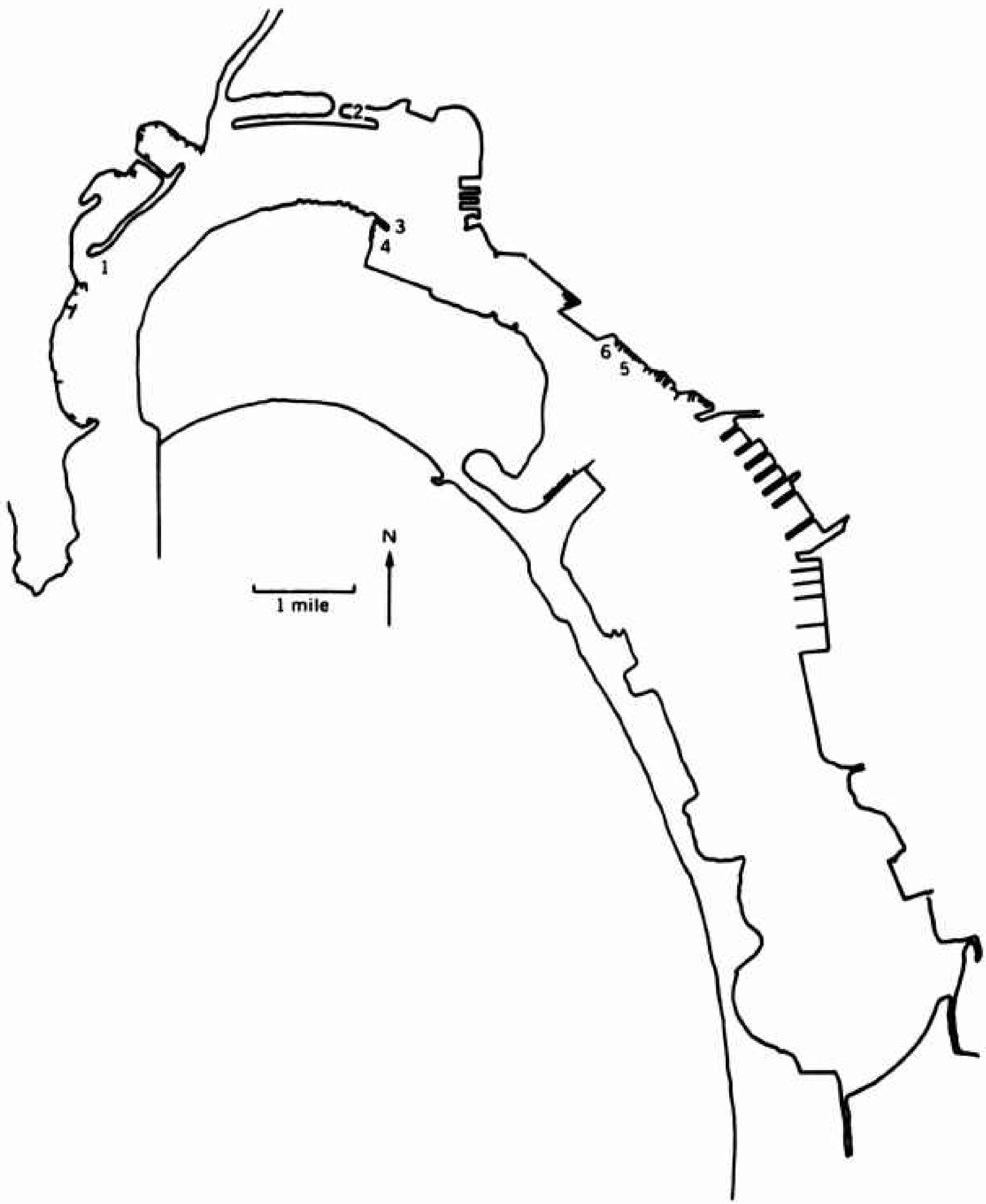

Figure C-2. Location of water sampling stations established in San Diego Bay by Lockheed Oceans Laboratory, 1970-1972.

c) Sediment sample data collected by U. S. Army Corps of Engineers, December 1971. Station locations are shown in figure C-3. (Source: U. S. Army Corps of Engineers, 1973.)

Parameter	Station Number												
	2	3	5	6	7	8	9	10	12	13	15	16	17
Volatile solids	2.0	6.6	5.9	3.4	5.1	4.3	4.1	4.1	8.2	4.2	8.5	9.0	1.4
Chemical oxygen demand	1.08	4.27	5.71	1.51	3.52	2.90	2.70	2.93	6.04	2.62	5.43	6.36	0.62
Total Kjeldahl nitrogen	0.070	0.148	0.237	0.082	0.108	0.062	0.115	0.105	0.183	0.085	0.125	0.138	0.024
Oil and grease	0.036	0.177	0.274	0.091	0.065	0.068	0.113	0.096	0.259	0.067	0.074	0.046	0.009
Iron	1.31	3.13	3.95	1.65	2.45	1.53	3.31	3.19	5.36	3.82	8.60	10.27	1.59
Mercury	0.33	0.50	0.84	0.08	0.33	0.76	0.48	0.77	0.68	0.74	0.30	0.50	0.82
Lead	10	21	43	23	23	30	21	28	28	15	21	13	6
Zinc	62	112	176	87	114	74	129	124	204	93	113	115	47
Cadmium	0.4	1.1	1.5	0.8	1.0	0.7	0.8	0.9	1.2	0.7	1.1	0.6	0.3
Copper	20	66	84	50	53	32	67	74	123	57	76	60	13
Chromium	14	37	55	21	32	19	41	40	68	34	54	57	17
Arsenic	0.39	0.14	0.53	0.36	0.39	0.39	0.46	0.47	0.65	0.35	0.5	0.56	0.56
Nickel	2	10	10	5	8	4	3	5	7	5	9	8	1
Total phosphorus	185	370	596	306	290	240	288	383	542	242	426	486	212
Sulfide	79	441	743	62	584	279	91	71	259	70	47	10	26

Note: Volatile solids, chemical oxygen demand, total Kjeldahl nitrogen, oil and grease and iron are given in percentage of dry weight; all other parameters are given in percentage of dry weight times 10^{-4}.

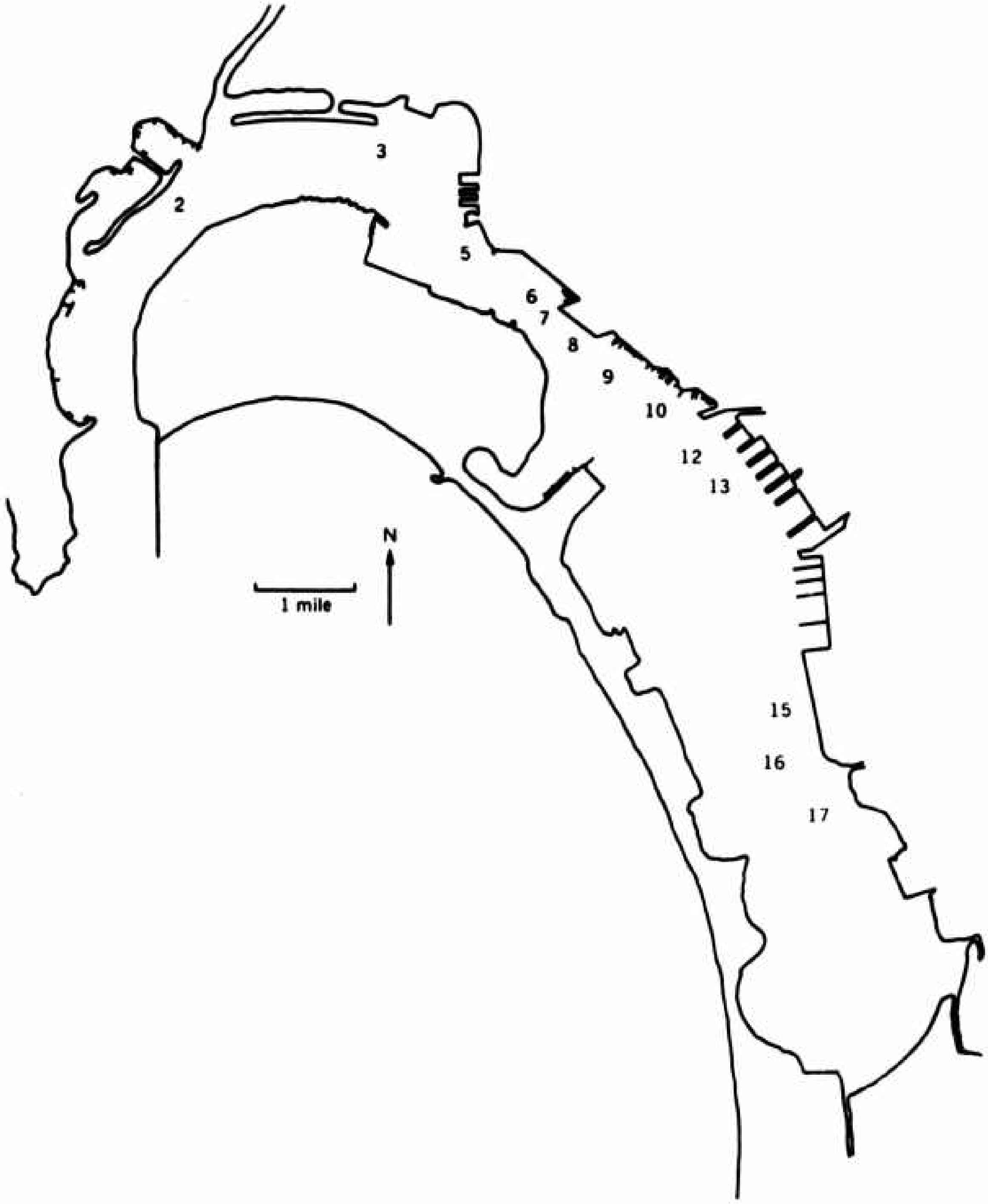

Figure C-3. Location of sediment sampling stations established in San Die... ...the U. S. Army Corps of Engineers, December 1971.

d) Sediment sample and water quality data collected by the Naval Undersea Center. Location of the sampling sites is shown in figure C-4. (Sources: S. Yamamoto and W. H. Shipman (Naval Undersea Center), unpublished data; Proximate Survey data.)

Sediment Data
(collected in September 1972; concentration in parts per million dry weight)

Distance [1]	Zinc		Lead		Chromium	
	Core 1	Core 2	Core 1	Core 2	Core 1	Core 2
Transect 1						
0 ft	22.7	---	9.8	---	137	---
50 ft	88.2	48.9	9.9	11.5	105	168
100 ft	54.6	54.2	11.7	17.8	168	230
150 ft	73.3	65.5	13.1	20.5	204	125
200 ft	34.4	44.2	16.7	16.8	59.1	59.6
300 ft	105.4	95.8	22.3	25.2	43.3	29.1
500 ft	234.2	238.9	37.3	70.4	78.8	60.0
Transect 2						
50 ft	25.3	32.7	6.1	6.1	96.7	109
100 ft	26.2	32.1	<5	<5	85.9	93.4
150 ft	35.3	125	5.6	7.0	206	86.1
200 ft	43.5	44.0	12.0	17.8	223	215
300 ft	45.3	29.8	6.2	7.6	31	24.3
500 ft	100	64.7	15.6	14.0	36	24.2

[1] Distance from source of industrial waste outfall.

Water Quality Data
(values given are means of nine samples taken between 23 April and 30 May 1973)

Parameter	Station									
	1	2	3	4	5	6	7	8	9	10
Temperature (°C)	15.1	16.1	17.1	17.5	17.6	18.7	18.3	18.9	19.0	18.7
Conductivity (mmhos)	42.1	43.3	44.0	44.4	44.6	45.6	45.3	45.9	46.3	46.1
Computed salinity (0/00)	34.3	34.6	34.4	34.4	34.5	34.6	34.3	34.5	34.6	34.8
Dissolved oxygen (ppm)	7.4	7.1	6.9	6.6	6.8	6.1	6.5	6.6	6.6	6.7

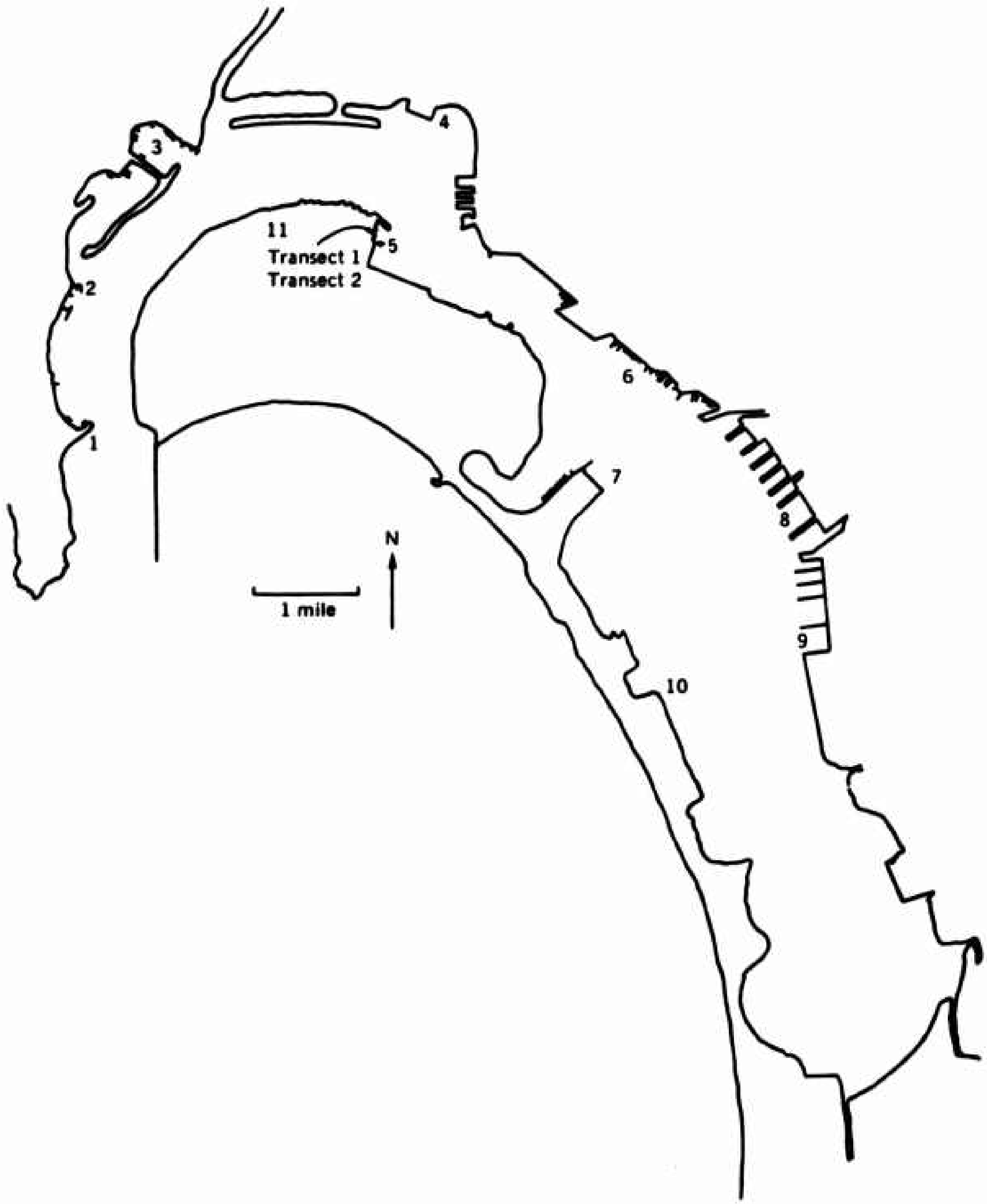

Figure C-4. Location of water (1-10) and sediment (11) sampling stations established in San Diego Bay by the Naval Undersea Center; April-May 1973 and September 1972.

APPENDIX D

Water Quality and Effluent Standards for the San Diego Region and Pacific Ocean Waters

(Source: Naval Civil Engineering Laboratory, 1972b.)

Parameter	Category: Heavy Metals	Bacteriological	Physical Property	Biostimulant	Solid Waste	Pesticide	Radiological	Other Organic	Other Inorganic	Standards: Limits — Percent of time stated limit is not to be exceeded. 50%	10%	Effluent Water	Receiving Water	Regulation Status
Dissolved Oxygen			x							≥7.0 mg/l annual mean			x	Adopted
										Not more than 10% below that which occurs naturally.			x	Proposed
Coloform Organisms		x								MPN ≤ 1000/100 ml.[a]			x	Adopted
										MPN ≤ 700/100 ml.[b]				
										MPN ≤ 1000/100 ml and ≤ 70/100 ml.[c]			x	Proposed
pH			x							7.0 ≤ pH ≤ 8.5			x	Adopted
										Not more than ±0.2 pH units charge from that which occurs naturally.			x	Proposed
										6.0 ≤ pH ≤ 9.0		x		Proposed
Temperature			x							Not more than 20°F increase.[d]			x	Adopted
										Not more than 4°F over 50% of the time at 1000 ft from discharge.			x	Adopted
Floatable waste					x					None visible.			x	Adopted
Transparency			x							Not less than 8 ft.[e]			x	Adopted
Odor			x							None other than natural.			x	Adopted
Color			x							None other than natural.			x	Adopted
Oil and grease								x		None visible.			x	Adopted
Ammonia (N)				x				x		40.	60.	x		Proposed
Arsenic									x	0.05	0.10	x		Proposed
Cadmium	x									0.02	0.04	x		Proposed
Total chlorine residual									x	1.0	2.0	x		Proposed
Total Chromium	x									0.2	0.4	x		Proposed
Copper	x									0.2	0.4	x		Proposed
Cyanide									x	0.1	0.2	x		Proposed
Floatable waste					x					1.0 mg/m²	1.5 mg/m²[f]		x	Proposed
Hydrocarbons, total identifiable chlorinated[g]						x				0.002	0.004	x		Proposed
Lead	x									0.05	0.1	x		Proposed
Mercury	x									0.005	0.01	x		Proposed
Nickel	x									0.2	0.4	x		Proposed
Oil and grease, petroleum fraction								x		15.	25.	x		Proposed
Total oil and grease								x		25.	40.	x		Proposed
										10 mg/m²	20 mg/m²		x	Proposed
True phenolic compounds							x			0.5	1.0	x		Proposed
Settleable solids					x					0.1 ml/l/hr	0.2 ml/l/hr	x		Proposed
Silver	x									0.02	0.04	x		Proposed
Suspended solids					x					50.	75.	x		Proposed
Toxicity (T_c)										1.5 TU[h]	2.0 TU	x		Proposed
										Not to exceed 0.05 TU final T_c.			x	Proposed
Turbity			x							50. JTU[i]	75. JTU	x		Proposed

APPENDI' D (Continued)

[a] Applies to at least 80 percent of the samples over any 30-day period.

[b] Applies to waters used for fish handling.

[c] Same sampling as in (a) but new zone defined. Lower limits apply to waters used for shellfish harvesting for human consumption.

[d] Applies to waters receiving output from heat exchange units.

[e] Applies to San Diego Bay only. Value is for more than 20 percent Sechi disc readings.

[f] Measure of areal concentration on water surface in milligrams per square meter.

[g] Sum of individual concentrations of DDT, DDE, BHC, aldrin, etc.

[h] Toxicity units.

[i] Jackson turbidity units.

NOTES:

1. Units are milligrams per liter unless otherwise specified.

2. Regulations listed as "Adopted" have been adopted by the San Diego Regional Water Quality Control Board, as stated in "Interim Water Quality Control Plan for San Diego Basin," June 1971.

3. "Proposed" applies to standards proposed by the California Water Resources Control Board. These proposals are under consideration and review by the San Diego Regional Water Quality Control Board, and those adopted will be included in the "Comprehensive Water Quality Control Plan for the San Diego Region," which should be finalized by early 1974.

APPENDIX E

Criteria of Environmental Protection Agency for Dredge Spoils Disposed of in Fresh or Marine Waters (Source: U. S. Army Corps of Engineers, 1973).

Constituent in Sediment	Concentration: Percent of Dry Weight	Concentration: Parts per Million
Volatile solids	6.0	60,000
Chemical oxygen demand	5.0	50,000
Total Kjeldahl nitrogen	0.10	1,000
Oil and grease	0.15	1,500
Mercury	0.0001	1
Lead	0.005	50
Zinc	0.005	50

APPENDIX F

Conversion Factors

To Convert	Multiply By	To Obtain
Atmosphere	33.9	Feet of water
Centigrade (degrees)	(°C x 9/5) + 32	Fahrenheit (degrees)
Centimeters	0.0328	Feet
Centimeters	0.3937	Inches
Cubic Centimeters	0.0004	Cubic Feet
Cubic Centimeters	0.061	Cubic Inches
Cubic Feet	28320	Cubic Centimeters
Cubic Feet	0.0283	Cubic Meters
Cubic Inches	16.39	Cubic Centimeters
Cubic Inches	0.0173	Quarts (liquid)
Cubic Meters	35.31	Cubic Feet
Cubic Meters	61023	Cubic Inches
Cubic Meters	1057	Quarts (liquid)
Cubic Yards	764600	Cubic Centimeters
Cubic Yards	0.7646	Cubic Meters
Fahrenheit	(°F x 5/9) – 32	Centigrade (degrees)
Feet	30.48	Centimeters
Feet of Water	0.0295	Atmosphere
Gallon	3785	Cubic Centimeters
Gallon	0.1337	Cubic Feet
Gallon	0.0049	Cubic Yards
Grams	0.0022	Pounds
Grams/Centimeter	0.0056	Pounds/Inch
Grams/Cubic Centimeter	62.43	Pounds/Cubic Foot
Grams/Cubic Centimeter	0.0361	Pounds/Cubic Inch
Grams/Liter	0.0624	Pounds/Cubic Foot
Inches	2.54	Centimeters
Kilograms	2.20	Pounds
Kilograms/Cubic Meter	0.0624	Pounds/Cubic Foot
Knots	1.853	Kilometers/Hour
Liter	0.0353	Cubic Feet
Liter	61.02	Cubic Inches
Liter	1.057	Quart (liquid)

To Convert	Multiply By	To Obtain
Meters	3.281	Feet
Meters	39.37	Inches
Meters	1.094	Yards
Miles (Nautical)	1.853	Kilometers
Miles (Nautical)	2025	Yards
Millimeters	0.0033	Feet
Millimeters	0.0394	Inches
Ounces	28.35	Grams
Ounces	0.0296	Liters
Pounds	453.59	Grams
Pounds/Cubic Inch	27.68	Grams/Cubic Centimeter
Quart (liquid)	946.4	Cubic Centimeter
Square Centimeters	0.0011	Square Feet
Square Centimeters	0.155	Square Inches
Square Feet	929.0	Square Centimeters
Square Inches	6.452	Square Centimeters
Square Meters	10.76	Square Feet
Square Meters	1550	Square Inches
Yards	91.44	Centimeters